Final Report

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Table of Contents

List of Terms and Abbreviations

agent-based model	ABM
Calgary Symptoms of Stress Index	cSOSI
Demands-Control Model	DCM
emergency call center	ECC
information and communication technologies	ICTs
Job-Demands-Resources Model	JD-R Model
Knowledge to Action Framework	K2A Framework
Mindful Attention Awareness Scale	MAAS
mindfulness-based intervention	MBI
"Next Generation 9-1-1"	NG911
Northwest Center for Public Health Practice	NWCPHP
post-traumatic stress disorder	PTSD
short message service	SMS
telecommunicator	TC

Project Title: From Multi-tasking to Hyper-tasking: Investigating the impact of Next Generation 9-1-1

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ABSTRACT

Emergency call centers (ECCs) are implementing "Next Generation 9-1-1" (NG911), which allows citizens to report emergencies using various digital technologies. The impact of NG911 on a highly stressed workforce in a high demand-low control work environment is a concern. Framed by the first NG911 technology being implemented—text-to-911—our study aimed to: understand health and performance risks associated with NG911 implementation; inform wellness approaches for mitigating those risks; and develop tools to forecast impacts on the 911 system whose mission is providing optimal emergency response to the public.

Aim 1 was an observational, prospective cohort study using repeated online surveys to capture pre-/post-NG911 implementation stress, job satisfaction, performance, and turnover intention. 275 telecommunicators (TCs) from 29 ECCs completed surveys before, one month, and 6 months post-implementation. We found higher stress levels associated with stress outside of work and mandatory overtime, lower stress levels associated with NG911 training support, and higher TC job satisfaction and positive performance self-assessment associated with training. However, we observed a statistically significant reduction in job satisfaction after text-to-911 implementation, a statistically significant association with intent to leave, and higher job dissatisfaction among TCs who received a text-to-911 call. Compared to voice calls, text-to-911 presents a challenge for patient safety and performance, as it is less information-rich and introduces communication delays. As NG911 is further deployed, it is probable that job satisfaction may decline and turnover may increase; however, training to improve skills and enhance confidence may reduce turnover intention.

ECCs primarily offer ongoing trainings that focus on maintaining or improving technical skills, but there is increased interest in wellness and health training. Mindfulness training is hypothesized to increase an individual's ability to regulate their emotional response to stressors. Aim 2 tested the efficacy of a seven-week online mindfulness-based intervention (MBI) specifically tailored to the 9-1-1 workforce. Following development and piloting of the MBI, 323 TCs were recruited and randomly assigned to the MBI or a control group. We observed significant reductions in stress scores in the intervention group compared to controls post- and at three-month follow-up. While there was no pre-/post-change in mindfulness scores between groups we did observe that greater positive change in mindfulness scores among the intervention group was associated with greater reductions in stress at both post-MBI time points. This suggests that greater improvement in mindfulness may be one of the mediating mechanisms by which intervention participants saw reductions in stress symptom scores.

How to introduce workplace modifications and improvements—such as changes in overtime or new trainings such as MBIs—may be enhanced by exploring impacts ahead of time. Aim 3 focused on building an agent-based model (ABM) for testing organizational staffing and management strategies that might buffer the impacts of ECC changes on its workforce. The tool was informed by Aims 1 and 2 measures. It will be used to conduct future work to understand the effects of specific new technologies on the workforce, for example workload effects, and to examine the effects of technologies on call processing level job performance.

SECTION 1

The overall objective of the "From Multi-tasking to Hyper-tasking: Investigating the impact of Next Generation 9-1-1" was to understand the health and performance risks associated with the implementation of NG911 technologies in the ECC workplace, design and develop a mindfulness-based wellness intervention as well as a worker support intervention to mitigate these risks and overall workplace stress, and develop tools to forecast impacts of NG911 implementation on the 911. The project was conducted by completing three Specific Aims, each of which generated key findings as summarized by Aim below.

1.1. Key Findings: Aim 1

Aim 1 activities focused on measuring levels of stress, job satisfaction and job performance among 911 TCs before and after the NG911 implementation. Significant findings generated from this observational, prospective cohort study included confirmation of higher stress levels associated with stress outside of work and mandatory overtime and lower stress levels associated with NG911 training support. In addition, on-the-job training was associated with higher TC job satisfaction and a positive self-assessment of performance. After implementation of text-to-911, we observed a statistically significant reduction in job satisfaction as well as a statistically significant association with intent to leave. In addition, job dissatisfaction was higher among TCs who actually received a text-to-911 call within 6 months of implementation when compared to those TCs who had not handled a call delivered through this new technology. Compared to 911 voice calls, text-to-911 presents a potential challenge for patient safety and performance, as it is less information-rich and introduces communication delays which are perceived by TCs as negatively impacting work performance and ability to dispatch appropriate care in medical emergencies. As more NG911 technologies are deployed, it is probable that job satisfaction may decline and intention to leave may increase. However, given the association between training and job satisfaction, performance and turnover intention, leveraging appropriate training to improve skills and enhance confidence may support morale and retention in ECCs undergoing NG911 deployments.

1.2. Key Findings: Aim 2

Aim 2 activities focused on developing and testing the efficacy of an evidence-based mindfulness-based intervention (MBI) and worker support Toolkit for managers that aimed to improve psychological well-being and job performance in ECCs, as measured by stress and mindfulness changes at baseline, post-MBI and at a three month follow-up and compared to a control group. Significant reductions in stress scores were observed in the intervention group at both post- and follow-up. A secondary analysis of pre-/post-change in mindfulness scores found higher baseline mindfulness scores in the intervention group than the control group although no statistically significant differences were observed in change in mindfulness between the intervention and control groups either post-intervention or at follow-up. However, we did observe that greater positive change in mindfulness scores among the intervention group was associated with greater reductions in stress at both post-MBI time points. Overall results indicated that greater improvements in mindfulness may be a mediating mechanism for stress reduction. A parallel activity focused on developing a toolkit of TC support resources for use by ECC managers. The toolkit includes resources for understanding stress, best practices for dealing with operational challenges, tools to reduce conflict in the workplace, wellness promotion, and stress management. Both this toolkit and the developed training intervention have been made available for free and are being widely used by the ECC/TC community.

1.3. Key Findings: Aim 3

Aim 3 activities focused on building an ABM tool of the ECC workplace to explore strategies to improve 911 TC workforce training and smooth transitions to future call center innovations. The

primary findings from this activity serve as proof of concept that it is possible to realistically model the complex behaviors, coordination and interactions in the ECC work environment and populate such a model using empiric data collected specifically to inform the model, rather than use data extrapolated from the literature or adjunctive studies. This work positions us to develop a working prototype of the ECC ABM and carry out a validation study of our results with real data to further understand the effects of new technologies on the workforce, including stress, absenteeism, turnover and job performance.

1.4. Translation of Findings

Within CDC's Knowledge to Action (K2A) Framework, our project is clearly situated under research phase discovery (Aim 1) and efficacy (Aim 2) studies that have been translated into products for dissemination and possible institutionalization into ECC practice (Aim 2) or for prototyping and iterative development (Aim 3). All project Aims and their associated research activities have been conducted with translation to practice in mind.

The on-line mindfulness training was developed to meet the needs of employees of high demand and low control worksites as well as industry needs. The mindfulness training was adapted from evidence-based work in MBSR to fit within the time-constraints of busy call centers and the Washington State Criminal Justice Training Commission Telecommunicator program recognized the training as continuing education for renewal of TC certificates. Since completion of the study the mindfulness training is readily available, free of cost, to all call center personnel. The on-line training has been automated to trigger weekly e-mails and lesson plans. Future studies need to focus on how to actively market this training to call centers nation-wide.

Similarly, the manager Toolkit was developed based on needs identified by call center managers. Given the low engagement with the toolkit during the study period we adapted the toolkit into a more formal on-line training for managers of call centers. This change has increased the number of individuals who have engaged with the toolkit and future research should investigate the most effective marketing strategies for increasing engagement with the training and uptake of workplace stress reduction recommendations. Both tools are available on the Northwest Center for Public Health Practice (NWCPHP) website.

1.5. Research Outcomes/Impact

Our public health emergency response system relies on TCs, the "first of the first responders," to handle the emergency needs of a public in distress. ECCs across the country have expressed concern that allowing citizens to place 9-1-1 calls using new digital technologies will increase stress, reduce job performance, lower employee retention, and/or change morale in a workplace that is already highly stressed due to the demanding nature of the work as well as ECC protocols around mandatory overtime. Understanding these impacts to inform approaches for mitigating the health and performance risks associated with new technologies is crucial for ensuring the 911 system fulfills its mission of providing optimal emergency response to the public. Findings from the Aim 1 pre-/post-text-to-911 implementation provide objective, rather than anecdotal, evidence that these concerns merit attention as well as interventions to reduce negative impacts on ECC worker health and safety and minimize turnover so a skilled workforce can be retained. Interventions developed by Aim 2 such as the MBI and associated manager resource toolkit that have proven their efficacy have the potential to mitigate these outcomes for TCs. And developing a tool as designed in Aim 3 to simulate interventions prior to their introduction can be useful for "forecasting" outcomes and unexpected effects of training or overtime protocols at minimal cost to the organization or its workers.

SECTION 2

2. Project Background

The effectiveness of the police, fire fighters and EMS paramedics depends on the TCs—emergency call takers and dispatchers—who are the "first of the first responders".[1] TCs prioritize and triage incoming calls, collect information for first responders and issue medical instructions to callers while help is on the way. Each TC fields thousands of calls that are unpredictable in volume, length and content every year while handling five to six computer screens during a single 9-1-1 call. Shifts are lengthy, 10- to 24-hours, non-standard (outside of 9:00AM to 5:00PM, Monday through Friday) and often coupled with mandatory overtime.[2] Our public safety relies on the TCs who must maintain the cognitive and emotional resources to perform complex, multiple tasks and make precise decisions with fateful consequences under life/death time pressures while staying calm.[3]

NG911 is a national initiative that requires all wireless carriers and providers of "interconnected" text messaging applications to support bi-directional transmissions between the public and ECC, including SMS (also known as text messaging) from a cellular phone, email, Skype or instant messaging.[4] In addition, NG911 will expand emergency information sources to include receipt of, interaction with and transmission of streaming video, photo uploads, and automatic crash notifications by ECCs.[5] This change is congruent with changes in the landscape of information and communication technologies and the public's expectations for sending a 9-1-1 text call or Twitter message during an emergency event.[6] NG911 capability will also improve access for deaf/hard of hearing populations and callers in a situation in which texting may be safer than calling, for example, during an active robbery.

Studies of technology adoption by ECCs have primarily focused on the ability of new technologies to improve the speed of emergency response, patient health outcomes and mortality, and hospital costs.[7] Preliminary studies have indicated that TC work is stressful and that this stress can be exacerbated when communication challenges affect efficient information gathering.[8-9] The impact of new ICTs and technology adoption on the psychological resiliency of those tasked with using the new technologies remains unknown. Also unknown, is whether the NG911 change in work tasks and, potentially, in call center organizational structure might increase stress, reduce job performance, contribute to maladaptive coping strategies or reduce the resilience of workers who must adopt the new technology. With the implementation of NG911, in addition to handling a serious call about domestic abuse or an automobile accident, a TC may be exposed to photo uploads of graphic physical injuries or streaming videos of fatalities on the Interstate—as well as need to issue character-limited text message instructions for clearing a blocked airway or administering CPR.

Our public safety relies on the TCs who must maintain the cognitive and emotional resources to perform complex, multiple tasks and make precise decisions with fateful consequences under life/death time pressures while staying calm.[3] Like the first responders they support, TC work is characterized by high demand and routine exposure to workplace stressors that are associated with a range of psychological and physical health consequences.[10] TCs are primarily involved in the initial response involved in an emergency and rarely play a part in final resolution or outcome of the call which may be a source of stress itself. TCs not only feel responsible for the safety of the public but also perceive themselves as responsible for the safety of the dispatched personnel.[11] And despite lack of a direct physical exposure to trauma, TCs also experience duty-related distress that enhances risk for adverse psychological outcomes. Peritraumatic stress—defined as the responses during or immediately after trauma exposure—have been shown to predict depression and post-traumatic stress disorder (PTSD)

among firefighters, police officers, emergency service personnel [12-13] and has recently been identified in the TC workforce.[14-15] Secondary trauma exposure has also been reported in TCs.[2] High levels of peritraumatic distress and a moderate, positive relationship between peritraumatic distress and PTSD symptom severity have been reported, suggesting that direct, physical exposure to trauma may not be necessary to increase risk for PTSD in this workforce.[15-16]

The adverse outcomes associated with exposure to acute and chronic occupational stressors are costly and include physical and mental diseases, and impaired work performance, which can threaten the attainment of an organization's critical mission(s).[17] Rameshbabu et al. (2013) reported that rotating shifts, common in 9-1-1 TCs, and their accompanying inadequate sleep were negatively associated with physical health outcomes in call center personnel.[18] Long hours of sedentary, high mental demand computer work, also ubiquitous in TCs, have been found to increase the risk for musculoskeletal symptoms [19] which can also be associated with psychological distress [20-21]. Workplace environmental conditions such as lighting, ventilation, temperature, break/lunch room availability, and workstation ergonomics have also been found to exacerbate work-related stress in TC workforces.[22-23] In addition, frequent technology updates including incremental and major "upgrades" in technologies, also common in the TC workplace, can cause "technostress" which has been shown in other worker groups to be associated with decreased job satisfaction and declines in productivity, commitment to the organization, and intention to remain on the job.[24]

Despite these findings, few studies have focused specifically on TC workplace stress, its health impacts, and ways to mitigate those impacts, although it is possible to extrapolate the benefits of training and wellness programs in other emergency service personnel. For example, MBIs—training that teaches and cultivates and individual's ability to pay attention and be aware of momentary experience with the goal of learning to recognize and accept stress responses [17]—and as been shown to be effective in mitigating stress in firefighters and paramedics and improving their ability to cope with, adapt to, and overcome the challenges of both routine and high-stress exposures [25] and is reported to be positively correlated with compassion satisfaction [26-27] and inversely correlated with compassion fatigue [28-30] and burnout.[31-33]

Our project, "From Multi-tasking to Hyper-tasking: Investigating the impact of Next Generation 9-1-1", sought understand health and performance risks associated with NG911 implementation; inform wellness approaches for mitigating those risks; and develop tools to forecast impacts on the 911 system whose mission is providing optimal emergency response to the public. The project was framed by the first NG911 technology being implemented—text-to-911. The project Specific Aims were to:

> Aim 1: Measure levels of stress, job satisfaction and job performance among 911 TCs before and after the NG911 implementation.
> Aim 2: Develop and test the efficacy of an evidence-based mindfulness training and worker support intervention to improve psychological well-being and job performance of TCs.
> Aim 3: Build an ABM tool of 9-1-1 call centers to improve TC workforce training and smooth transitions to future call center innovations.

While inter-related, each aim was conducted utilizing an aim-specific methodology derived from its conceptual framework. Section 2 is thus organized by specific aim.

2.1. Aim 1

Specific Aim 1: Measure levels of stress, job satisfaction and job performance among 9-1-1 telecommunicators before and after the NG911 implementation

2.1.1. Aim 1 Background

Aim 1 was designed to specifically address the following research question: How will NG911 implementation affect TC stress, job performance, and job satisfaction?

Research on workplace stress in call centers has reported associations with attrition, burnout, absenteeism and early retirement. While limited to call centers in WA State, findings from our project team's pilot study found that 42% of TCs assess their job as "stressful to very stressful" and 60% reported their job as demanding (47%) or extremely demanding (14%), with no differences by gender or years of service, suggesting that stress levels do not abate over time.[34] The cost of this demanding workplace cannot be ignored. A 2012 survey found that 63% of emergency center managers associated job stress with TC turnover.[35] Although there is great variety in size, location and type, 83% of centers in a call center retention study reported an increase in the number of dispatched calls as compared to the previous three years while struggling with a national average annual turnover rate of 19%.[36] "Burnout" (a combination of exhaustion, cynicism, job detachment, a sense of ineffectiveness and lack of accomplishment or perceived lack of recognition/appreciation [37] was identified as a primary cause of these lowered retention rates. Research has also positively associated TC burnout with both sickness- and work-related absenteeism [38], an increased likelihood of lower job performance [39], depressive symptoms and lower job/life satisfaction.[40]

Workplace factors, such as perceived manager support, sense of control over one's schedule and social relationships with co-workers, including workplace climate characteristics such as bullying/harassment, can all influence stress levels and outcomes.[38-39,41-42] Individual characteristics, such as overcommitment (an exhaustive pattern of coping associated with the inability to withdraw from work demands) has been positively associated with high stress scores in TCs.[34] However, a variety of factors, both environmental and individual, may buffer the impact of negative outcomes associated with stress. Lifestyle factors, such as physical activity, and emotion-regulating skills can reduce the impact of environmental stressors as can work-life balance.[39-41,43] In addition, individual characteristics and differences, such as coping strategies, self-efficacy, resiliency and compassion satisfaction can play a part in reducing or ameliorating high levels of work-related stress.[44-49]

To date, studies of technology adoption by ECCs have primarily focused on the ability of new technologies to improve the speed of emergency response, patient health outcomes and mortality, and hospital costs.[50] "Technostress" is defined as stress created by adoption of information and communication technologies which can impact worker productivity, job satisfaction, commitment to the organization, and retention.[24,51] Another issue specific to text-to-911 calls is TCs reliance on verbal communication to obtain and convey critical, clear, time-sensitive information, as well as take the caller's language, voice, tone and auditory background and surroundings into account in order to successfully delivering lifesaving information.[52] Research has found that when communication challenges affect efficient information gathering, TC stress can be exacerbated.[53-54] Other NG911 implementation impacts of concern are possible health impacts.[52] While 9-1-1 TCs will receive training to adapt to the new technologies deployed through the NG911 initiative, the focus is solely on technical skills, not human resource skills such as how to handle psychological stress due to hyper-tasking, exposure to multi-media images (to which TCs have not historically been

exposed and which may enhance peritraumatic distress and thus, heighten risk for PTSD), or cumulative stress effects that could increase risk for stress and mood-related disorders. Exposure to photo uploads of graphic physical injuries or streaming videos of fatalities on the Interstate may increase occupational stress and distress. In addition, it is unknown how performance might be impacted, for example, when a TC needs to issue character-limited text message instructions for clearing a blocked airway or administering CPR.

Aim 1 sought to measure the impact of NG911 technology changes on stress, job performance, maladaptive coping strategies, and employee retention in the workplace. Understanding these impacts to inform approaches for mitigating the health and performance risks associated with new technologies is crucial for ensuring the 911 system fulfills its mission of providing optimal emergency response to the public. An additional objective of Aim 1 was to determine the suitability of the JD-R model for studies in the 9-1-1 call center environment, as described in the next section.

2.1.2. Aim 1 Conceptual/Theoretical Framework

On a broad level, the field of occupational health seeks to understand the interconnected roles of job demands, job controls, and job resources on stress. In the 9-1-1 call center environment, call takers are the most essential human resource and asset for ensuring the safety of the public and the personnel who respond to an emergency. Two conceptual frameworks inform Aim 1: the Demands-Control model (DCM), which links job characteristics (e.g., low levels of control and work overload) to job stress and stress-mediated health outcomes [55-56] and the Job-Demands-Resources (JD-R) Model, one of the most influential and comprehensive stress and motivation models being applied in work studies, which stipulates that both demands and resources (such as supervisor support) can have multiplicative or cumulative effects on job stress and stress-related outcomes such as attrition and turnover intention, burnout/exhaustion and absenteeism (illness and work-related).[57-58]

The DCM focuses on the psychosocial job characteristics of job demands and job control (sometimes referred to as decision latitude) within the context of the interactions between a worker and the environment, and the importance of identifying extent of worker decision authority (control over work situation) and skill discretion (possibility of using skills and competencies). High demands and low control predict "high-strain" which leads to increased levels of depression, fatigue and cardiovascular disease and mortality. Workers with high control are buffered from the negative effect of demands on outcomes which leads to lower levels of illness.[55] Social support also can act as a buffer in high demand situations.[59-61] In the context of NG911 technologies implementation, the DCM suggests that a technology change such as text-to-911 will create a "High Strain" work environment with TCs at higher risk for elevated stress and related health problems which would influence the likelihood of higher turnover intention and absenteeism and reduce job satisfaction and job performance.

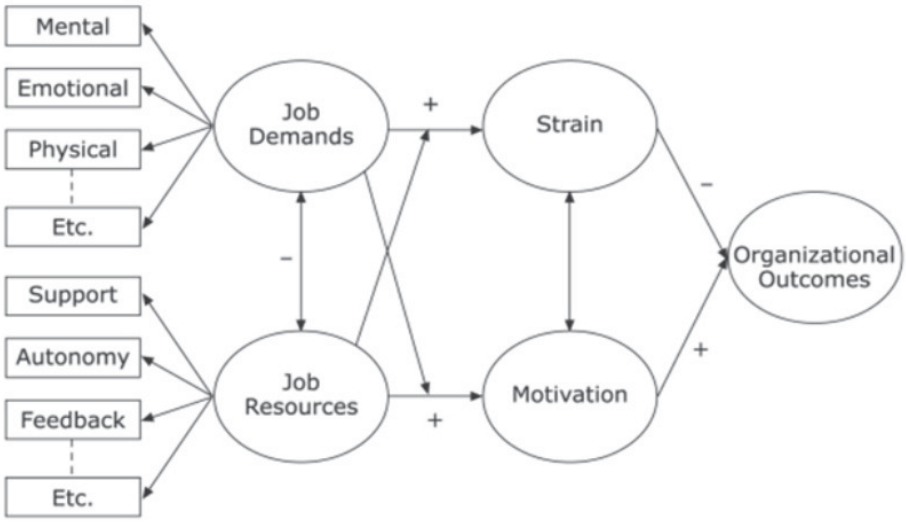

Fig. 1. JD-R model [57-58]

However, TCs already work in a high strain work setting and adding more stressors could exacerbate an already taxed and burnt out workforce. The DCM cannot explain why the same levels of demand and control in two workers of similar background can lead to differential behavioral or health outcomes [62] or that there are different types of demand, some of which may be positive, such as the challenge of learning a new skill.[63-64] The JD-R Model, as illustrated in Figure 1, expands on the DCM by including resources: aspects of the workplace that help with achievement of work goals, reduce demands or stimulate growth and development. In this model resources of all types can buffer the impact of demands on stress outcomes [57] and also incorporates personal characteristics that contribute to resiliency to stress, such as self-efficacy, organizational-based self-esteem, and optimism, among others.[58]

2.1.3. Aim 1 Methodology

Design. Aim 1 design consisted of an observational, prospective cohort study framed by text-to-911 calling, the first new technology implemented as part of NG911. Our primary outcome was changes in symptoms of stress as measured by the Calgary Symptoms of Stress Index (cSOSI) [65] that occur with the introduction of NG911 technologies. Of primary interest were comparisons between pre-NG911 implementation and post-implementation stress levels, both immediately and long-term. Data was collected by online surveys distributed at each center according to the following timeline: 4-8 weeks before text-to-911 implementation; within the first month of implementation; and 6 months after implementation. In addition to collecting data regarding the type of and frequency with which respondents experienced physical, psychological, and behavioral stress responses during the designated time frames, data regarding use of sick leave in the previous month; self-reported job performance; self-reported job satisfaction and technostress were captured at each time point. Given text-to-911 was deployed at different times at different call centers, data collection was staggered and tailored to the implementation timeline at each participating ECC.

Instruments. Data was collected through administration of the following online instruments:

Demographic Enrollment Information: TCs were asked to provide the following at enrollment: Gender, Age Range, Educational Level, Position/Role and Years Worked as TC.

Pre/post TC Surveys: Surveys included items regarding personal stress from the cSOSI (56 items with 8 subscales were included: cardiovascular, muscle tension, neurological/GI, depression, anger, sympathetic arousal, upper respiratory and cognitive disorganization). The cSOSI asks the frequency of occurrence of each item in the previous month using a 5 point scale (0=never to 4=very frequently). Additional survey items (see Table 1) collected primary outcome variables of interest and potential moderators on their effects: job performance self-assessments, job satisfaction, impact of technologies (anticipated and actual) on performance, workplace support (colleague, supervisor, and training), workplace demands (such as mandatory vs. voluntary overtime), and turnover intention. In addition, we collected current shift, partner status, sick days taken (last month), vacation taken (last month), stressful calls (last month), and regular exercise self-reports at each timepoint. Table 1 lists each construct and the instruments incorporated into the Aim 1 pre/post-TC surveys.

Table 1. Summary of Data Collected by Online Surveys Administered to TCs	
1A. Primary Outcome Variables and Definition	
Stress	Symptoms of stress [65]
Job Satisfaction	Attitudes and feelings about work, ranging from positive (indicating job satisfaction) to negative (indicating job dissatisfaction) [51,66]
Job Performance: Perceived Usefulness & Utility	Perceptions regarding how using a particular system will enhance job performance (perceived usefulness) and be utilized with little effort (perceived ease of use) [67-69]
Job Performance: Job-Fit/Job Complexity	Expectations regarding complexity of a system and impact on job performance [70]
Job Performance: Professional Efficacy	Extent to which workplace demands can be met [58]
1B. Moderators	
Support Satisfaction	Perceptions of manager and co-worker social support as direct sources of stress as well as potential job resources [22,57,66,71-72]
Network Conflict	Perceptions of manager and co-worker conflict as direct sources of stress and which influence appraisal of occupational stressors [66]
Multi-tasking	Having to handle several, multiple, possibly overwhelming tasks; perception of impact of technology overload, uncertainty, and/or complexity [22,24,51,73-74]
Technologies & Task Load	Stress experienced by end users in organizations as a result of their use of ICTs, constant ICT changes and the physical, social and cognitive responses demanded by their use. [24,51]
Overcommitment	An individual's exhaustive coping style which can adversely impact health [34,73,75]
Attitude toward Behavior	Positive or negative feelings about performing the target behavior [68,76]
Turnover Intention	Intention to leave or stay at current place of employment [77]
Absenteeism	Absence from work (illness-related vs work-related illness) [57,71]
Specific Technologies	Perceptions of anticipated and actual impact of specific NG911 information sources on performance [78]
Work-Life Balance & Job Satisfaction	Extent to which an individual is engaged in, satisfied by and balances different life roles [79]

Online Manager Survey: At each data collection point managers were asked to update call center information regarding absenteeism, vacancies, etc. as well as indicate number of hours they have had to fill in for TCs due to absenteeism, training or low census, their current work-related stress level and their perception of overall stress level at the call center.

Analysis. All analyses were conducted using the R statistical software.[80]

The primary outcome variables were cSOSI score and job satisfaction. Collected data was analyzed using multilevel models to examine changes in outcome measures over time and associations with technology changes. The primary analyses used mixed effects regression models (for continuous outcomes) and mixed effects logistic regression models (for binary outcomes) to estimate the change in outcome variables associated with technology implementation. The models included fixed effects for time (three levels; baseline, post implementation and follow up) and site, with a random intercept for participant to estimate the change in outcome variables associated with text-to-911 implementation. Because not all participants received texts at the second and third time points we included having processed a text-2-911 in the previous month as a covariate in each model in a third set of models.

Association between baseline outcome measures on survey non-response for the post-implementation survey was examined to assess if survey non-response was associated with the outcome measures. In the situation that a statistically significant association was observed we conducted a sensitivity analysis to determine the extent to which the observed association could account for association between the outcome variables and implementation of technology by using multiple implementation to impute missing outcomes according to different levels of differential drop-out. Hypotheses were conducted at the 0.05 level of significance with adjustment for multiple comparisons between time periods.

Multiple secondary analyses examined effects of stress on absenteeism; associations between technology attitudes and stress; effects of implementation on attitudes towards technology; and mitigating effects of job demands, job satisfaction, attitudes towards workplace technology and workplace support on change in stress.

2.1.4. Aim 1 Results

Figure 2 illustrates Aim 1 enrollment and study flow.

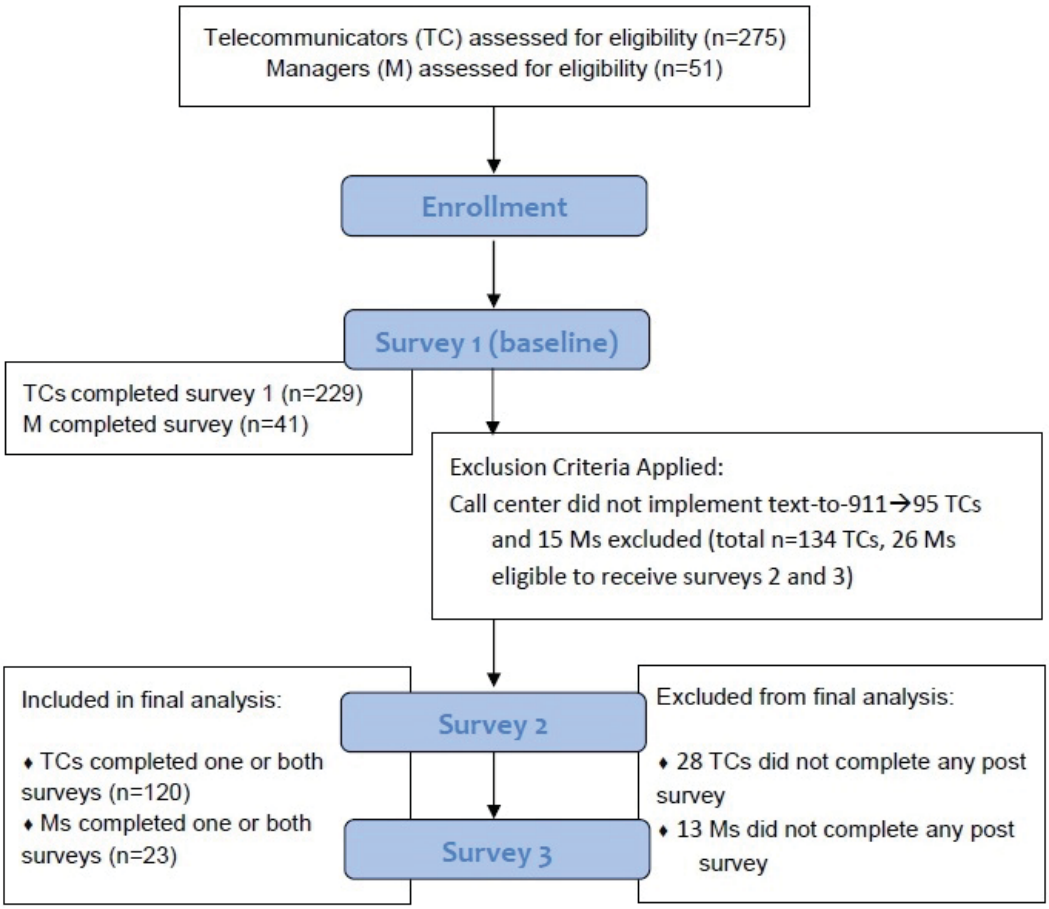

Fig. 2. Aim 1 CONSORT Flow Diagram

Table 2 summarizes overall enrollment and survey participation for TCs and managers at each time point. Participants with baseline responses and responses for at least one of the remaining time points were included in the analyses although not all participants with baseline (survey 1) responses participated in both the post (survey 2) and follow-up (survey 3) surveys.

Table 2. Overall Enrollment and Participation Summary Statistics			
	Baseline (Survey 1)	Survey 2*	Survey 3
TC (n)	229	113	102
M (n)	44	23	22
ECC (n)	29	19*	19*
*only ECCs that implemented text-to-911 eligible for surveys 2 and 3			

Not all participants with baseline (survey 1) responses participated in both the post (survey 2) and follow-up (survey 3) surveys. Response rate is summarized in Table 3A. Table 3B summarizes covariates and outcomes measured at each time point.

Table 3. TC Survey Summary Statistics Details												
3A.	**Baseline (Survey 1)**				**Survey 2**				**Survey 3**			
	n miss-ing	**No %**	**Yes %**		**n miss-ing**	**No %**	**Yes %**		**n miss-ing**	**No %**	**Yes %**	

preferred Shift	1	29.4	70.6	11	23.9	76.1	25	20.0	80.0
Stress outside	0	40.0	60.0	10	49.1	50.9	26	45.7	54.3
any Mandatory Overtime	0	27.5	72.3	10	0.27	0.73	25	22.1	77.9
any Voluntary Overtime	0	33.3	66.7	10	36.4	63.4	25	0.32	0.68
any Sick Days	0	64.2	35.8	10	52.7	47.3	25	55.8	44.2
Intention to leave	55	73.8	26.2	10	74.5	25.5	25	69.5	30.5
3B.	**n miss-ing**	**mean**	**sd**	**n miss-ing**	**mean**	**sd**	**n miss-ing**	**mean**	**sd**
Supervisor Support	0	38.6	14.88	10	30.4	9.4	25	30.5	8.4
NG911 training support	0	9.24	3.02	10	9.62	3.12	26	9.53	2.89
Job Satisfaction	0	3.24	0.7	12	3.05	0.71	25	3.216	0.61
cSOSI	1	72.1	36.5	12	68.1	36.2	25	69.7	37.6
SOSI_Symp*	0	1.65	0.86	11	1.61	0.88	25	1.57	0.85
SOSI_Cardio*	0	0.79	0.87	10	0.72	0.85	25	0.75	0.74
SOSI_Resp*	1	1.37	0.76	10	1.30	0.80	25	1.42	0.92
SOSI_Neuro*	1	0.67	0.71	10	0.62	0.69	25	0.71	0.70
SOSI_Muscle*	0	2.16	1.01	10	2.08	1.05	25	2.08	1.10
SOSI_Depress*	0	0.97	0.87	10	0.92	0.87	25	0.88	0.82
SOSI_Cogn*	0	0.75	0.67	11	0.71	0.65	25	0.74	0.70
SOSI_Anger*	0	1.53	0.90	11	1.42	0.88	25	1.44	1.00
* 0 – 4 scale									

Table 4 describes baseline associations between covariates and outcome measures. Stress outside of work and mandatory overtime where positively associated with stress levels, while NG911 training support was negatively associated with stress levels. For job satisfaction voluntary overtime was negatively associated with job satisfaction while NG911 training support was associated with higher job satisfaction.

Table 4. Baseline Association with Stress, Job Satisfaction, Use of Sick Leave and Turnover Intention

4A. Stress		coefficient	S.E.	z-value	p-value
Preferred Shift		-7.94	7.12	-1.11	0.272
Stress outside of work		15.18	6.32	2.40	0.022
any Mandatory Overtime		22.60	7.56	2.99	0.003
any Voluntary Overtime		-9.25	6.78	-1.36	0.173
Supervisor Support		-1.97	0.66	-3.00	0.003
NG911 Training support		-3.82	1.05	-3.64	0.000
Performance		-12.78	3.58	-3.57	0.000
Job Satisfaction		-9.54	4.96	-1.92	0.054
4B. Job Satisfaction		coefficient	S.E.	z-value	p-value
Preferred Shift		-0.03	0.13	-0.25	0.809
Stress outside of work		-0.18	0.12	-1.50	0.133
SOSI		0.00	0.00	-1.96	0.049
any Mandatory Overtime		0.10	0.14	0.69	0.515
any Voluntary Overtime		-0.26	0.12	-2.13	0.033
Supervisor Support		0.02	0.01	1.34	0.182
NG911 Training support		0.04	0.02	2.10	0.035

Performance		0.20	0.07	3.00	0.003
4C. Any Sick Leave	odds	coefficient	S.E.	z-value	p-value
Preferred Shift	1.05	0.05	0.45	0.12	0.907
Stress outside of work	2.48	0.91	0.44	2.07	0.039
SOSI	1.01	0.01	0.01	2.39	0.017
any Mandatory Overtime	0.82	-0.20	0.48	-0.41	0.679
any Voluntary Overtime	1.96	0.67	0.45	1.50	0.134
Supervisor Support	0.98	-0.02	0.04	-0.56	0.574
NG911 Training support	0.92	-0.08	0.07	-1.17	0.243
Performance	0.65	-0.44	0.25	-1.77	0.077
Job Satisfaction	0.74	-0.31	0.31	-0.97	0.331
4D. Turnover Intention	odds	coefficient	S.E.	z-value	p-value
Preferred Shift	0.82	-0.20	0.73	-0.28	0.781
Stress outside of work	3.00	1.10	0.69	1.59	0.112
SOSI	1.02	0.02	0.01	1.67	0.095
any Mandatory Overtime	0.74	-0.30	0.59	-0.51	0.611
any Voluntary Overtime	0.80	-0.23	0.63	-0.36	0.719
Supervisor Support	0.90	-0.10	0.06	-1.70	0.088
NG911 Training support	0.80	-0.22	0.13	-1.68	0.093
Performance	0.50	-0.69	0.44	-1.58	0.114
Job Satisfaction	0.37	-0.98	0.49	-2.02	0.044

Table 5 describes perceptions of the impact of the four NG911 technologies on performance and safety in comparison to standard 911 voice calls before and after implementation of text-2-911. TCs rated each technology using a 7 point Likert-type scale to capture perceptions regarding impact of new technologies on: helpfulness for decision making and conveying pre-arrival instruction; quality and usefulness of the information in a call; time to process a call; quality of job performance; ability to protect responders' safety; and ability to protect safety of the public. Prior to implementation, impact of text-2-911 on performance was uniformly perceived more negatively than Onstar, Smart911 or Visuals ($p < 0.05$ for all comparisons). The greatest differences in perceived effect on performance between text-2-911 and the other technologies were in ability get sufficient information and timeliness of response, both of which are important for dispatching appropriate care in medical emergencies. After implementation, no statistically significant differences were observed in perception of performance of text-2-911 ($p = 0.699$).

Table 5. Perceptions of text-2-911, Onstar (automobile crash notification), Smart911 (pre-registration of household emergency information) and visuals (photographs and streaming videos of an emergency incident) on performance and safety compared to voice calls.

	Text-2-911		**Onstar**		**Smart**		**Visual**	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Helpfulness	3.1	(2.9, 3.3)	3.8	(3.6, 4.0)	4.2	(3.9, 4.5)	3.9	(3.6, 4.1)
Information	2.5	(2.3, 2.7)	3.5	(3.3, 3.7)	4.6	(4.3, 4.9)	4.2	(3.9, 4.4)
Instruction	2.5	(2.3, 2.7)	3.2	(3.0, 3.4)	3.8	(3.5, 4.0)	3.6	(3.3, 3.8)
Interactions	2.8	(2.6, 3.0)	3.4	(3.2, 3.6)	4.2	(3.0, 4.4)	3.3	(3.0, 3.6)
Performance	3.7	(3.5, 3.8)	3.9	(3.8, 4.1)	4.2	(4.0, 4.4)	3.9	(3.7, 4.1)
Safety of Public	3.2	(2.9, 3.4)	3.7	(3.5, 3.9)	4.2	(3.9, 4.4)	4.1	(3.8, 4.3)
Responder Safety	3.1	(2.8, 3.3)	3.7	(3.5, 3.8)	4.2	(3.9, 4.3)	4.2	(3.9, 4.4)
Timeliness	2.1	(1.9, 2.3)	3.6	(3.4, 3.8)	3.7	(3.4, 3.9)	2.8	(2.5, 3.0)

Table 6 shows the estimated change in outcome measures—cSOSI, job satisfaction, perceptions of impact of text on performance, use of sick leave, and turnover intention—between time points along with the effect of having received a text. No statistically significant changes were observed in cSOSI, assessment of text performance or use of sick leave. A statistically significant reduction in job satisfaction between baseline and time point 2 was observed and the effect of having received a text was also statistically significant, with those who had received a text having a lower job satisfaction than those respondents who had not received a text-to-911 call. Table 6 also shows a statistically significant association between intent to leave and time points ($p = 0.038$), with later time points showing a higher odds of leaving (however pairwise comparisons between time points were not statistically significant).

Table 6. Change in Outcome Measures between Time Points and Effect of Receiving a text-to-911 Call

6A. cSOSI		**Estimate**	**SE**	**p-value**
Time 2 - Time 1		-2.98	1.70	0.187
Time 3 - Time 1		-1.02	1.79	0.836
Time 3 - Time 2		1.96	1.88	0.549
Received text effect		-0.03	2.72	0.992
6B. Job Satisfaction		**Estimate**	**SE**	**p-value**
Time 2 - Time 1		-0.18	0.05	0.002
Time 3 - Time 1		-0.09	0.06	0.281
Time 3 - Time 2		0.10	0.06	0.236
Received text effect		-0.18	0.008	0.031
6C. Text performance		**Estimate**	**SE**	**p-value**
Time 2 - Time 1		-0.11	0.09	0.426
Time 3 - Time 1		-0.10	0.09	0.518
Time 3 - Time 2		0.01	0.10	0.998
Received text effect		-0.13	0.13	0.317
6D. Sick leave	**Odds ratio**	**Estimate**	**SE**	**p-value**
Time 2 - Time 1	1.11	0.10	0.05	0.163
Time 3 - Time 1	1.07	0.06	0.06	0.513
Time 3 - Time 2	0.96	-0.04	0.06	0.835
Received text effect	0.97	-0.03	0.07	0.720
6E. Intent to leave	**Odds ratio**	**Estimate**	**SE**	**p-value**
Time 2 - Time 1	0.99	-0.01	0.04	0.919
Time 3 - Time 1	1.06	0.06	0.04	0.321
Time 3 - Time 2	1.07	0.07	0.03	0.099
Received text effect	0.93	-0.08	0.05	0.140

2.1.5. Aim 1 Discussion

Although call centers expressed concern about effects of NG911 on work stress, we did not observe a change in stress after implementation of one of the NG911 technologies--text-2-911--nor an increase in use of sick leave. It is possible that, unlike exposure to photo uploads of graphic physical injuries or streaming videos of fatalities on the Interstate, the text-2-911 NG911 technology may not have an impact on TC stress. However, text-2-911 does require TCs to issue character-limited text message instructions and we observed a reduction in job satisfaction as well as a corresponding increase in intention to leave between baseline and

surveys 2 and 3. We are able to attribute this association to text-2-911 with the observed association between job satisfaction and having received a text.

Of the four NG911 technologies TCs were asked to rate, text-2-911 was rated the most negatively in terms of effect on performance of the 911 system. While text-2-911 is inherently less informative than other technologies (including the phone), this communication format also conveys less emotional content so it may not impact stress the way other technologies will; however, text-2-911 may reduce job satisfaction because it is simply more difficult for TCs to respond appropriately without contextual information such as background noise or caller tone of voice.

Our study finds that text-2-911 is the greatest challenge for patient safety and performance. Overall, text-2-911 creates slower and less information-rich communications compared to 911 voice calls. For some emergencies (for ex, domestic violence), text-2-911 offers a communication channel that would otherwise be unavailable – this improves EMS response and provision of appropriate care. However, we also observed an association between training and job satisfaction: TCs' confidence in receiving appropriate training was associated with job satisfaction and a positive self-assessment of performance. Providing training to improve skills and enhance confidence may reduce turnover intention due to job dissatisfaction.

Given the association between turnover intention and having received text-2-911 observed in this study, as more of the NG911 technologies are deployed downstream, it is probable that job satisfaction may decline and intention to leave may increase.

2.1.6. Aim 1 Conclusions and Impacts

To date, studies of technology adoption by emergency call centers have focused on the ability of new technologies to improve the speed of emergency response, patient health outcomes and mortality, and hospital costs. The stress created by adoption of information and communication technologies can impact worker productivity, job satisfaction, commitment to the organization, and retention. While 9-1-1 TCs receive training to adapt to the new technologies deployed through the NG911 initiative, the focus of this training is solely on technical skills, not human resource skills such as how to handle psychological stress or cumulative stress effects. Stressful and hazardous conditions such as exposure to psychological stress have implications for TCs' work life quality, safety and health. Our public health dependence on TCs for our security and safety makes it imperative that the impact of technological changes such as the NG911 initiative are researched so appropriate intervention efforts to protect TCs can be developed. Failing to protect our 9-1-1 TC workforce from predictable health risks would be similar to knowingly exposing field emergency responders to a toxic situation without following OSHA required training and practice standards assuring their protection.

Call centers need to anticipate the impact of NG911 technologies on performance and patient safety, and take steps to ensure that patient safety is not compromised. For example, encouraging texters to place voice calls is being used by some call centers that implement text-2-911. Other call centers are conducting public safety announcements that encourage texters to limit texting only to situations when voice calls are not possible, such as a domestic violence situation.

Aim 1 examined the associations among stress, job satisfaction, job performance and stress-related outcomes in 9-1-1 call centers. While focused on 9-1-1 call takers, outcomes of this study have much wider impacts as interventions to reduce stress related to technical advances and their adoption might benefit other workforce groups. In addition, this study provides

significant guidance regarding how to best leverage resources that can reduce stress, sustain job performance, maintain job satisfaction and potentially reduce stress-related outcomes such as attrition, turnover intention and work-related illness. In addition, the findings from Aim 1 are confirmatory and largely consistent with the JD-R model, in that support such as training is associated with work engagement and satisfaction and can serve as a resource to moderate job demands and stress. More studies applying the JD-R model in this work environment is needed to construct intervention measures to improve call takers' well-being. Future work also should be extended to include other factors such as the cognitive and emotional demands of call taker work and the role of personal resources (such as resilience) in moderating stress and call taker well-being.

2.2. Aim 2

Specific Aim 2: Develop and test the efficacy of an evidence-based mindfulness training and worker support intervention to improve psychological well-being and job performance of TCs

2.2.1. Aim 2 Background

The adverse outcomes associated with exposure to acute and chronic occupational stressors are costly and include physical and mental diseases, and impaired work performance, which can threaten the attainment of an organization's critical mission(s) [81]. In addition to trauma exposures, 9-1-1 TCs are subject to those stressors commonly encountered by non-ECC workforces, including: fast-paced and time-urgent decision-making; tense interactions with distressed and sometimes abusive callers; time pressure to meet call processing requirements; and a negative work culture, which can include co-worker conflict, and a lack of appreciation or recognition from supervisors.[22-23] Long hours of sedentary, high mental demand computer work, also ubiquitous in TCs, have been found to increase the risk for musculoskeletal symptoms [19] which can also be associated with psychological distress.[20-21] Workplace environmental conditions such as lighting, ventilation, temperature, break/lunch room availability, and workstation ergonomics have also been found to exacerbate work-related stress in TC workforces.[22-23] **To address occupational stress in TCs we developed two different interventions: an individual-level mindfulness intervention focused on improving individual TCs' ability to regulate emotions and a stress reduction Toolkit to assist managers' in reducing social and physical workplace stressors**.

Mindfulness and Stress: While there is no universally agreed upon definition, mindfulness can be defined as the individual's ability to pay attention to and be aware of present moment experience, closely observe and describe sensations, perceptions, thoughts, and feelings, and act with full awareness.[82]. A growing literature base has established the salutary effects of mindfulness-based interventions (MBIs). MBIs model, teach and cultivate the inner attentional resources of a trainee with the goal of learning to recognize and accept stress responses. Through recognition and acceptance, individuals learn to no longer rely on avoidance or suppression of emotional responses. Avoidance and suppression of emotional responses have been connected to greater stress levels and psychopathology following exposure to distressing events.[17,83-86] Mindfulness has been reported to be positively correlated with compassion satisfaction [87-88] and inversely correlated with compassion fatigue [89-91] and burnout.[32-33,92] Mindfulness has also been associated with reduced stress in firefighters and paramedics [93] and MBIs have also been associated with fewer PTSD symptoms in combat veterans[94-99] Specific to 9-1-1 TCs, a recent cross sectional/non-intervention study showed that increased mindfulness was inversely correlated with self-reported symptoms of stress.[34] And regarding delivery of mindfulness training, *online* MBIs have been shown to be effective in a number of workplace settings.[100-106]

Worksite Environment and Stress: In occupations such as the 9-1-1 TCs', in which work demands are high and worker control is low, employee wellness and stress-mediated outcomes can impact attrition, turnover, burnout/exhaustion and absenteeism.[58,60] Worksite characteristics affect employees' productivity, satisfaction, and stress; however, an array of interventions may improve the quality of the work environment, and worksite health promotion activities can support employees' healthy behaviors. The role of managers in particular, as a resource and support to employees has been highlighted as a significant component of organizational-level interventions that can reduce or mitigate stress.[35,55,57] In addition, interpersonal conflict between employees is a stressor amenable to intervention, for example,

by training supervisors to adopt strategies for conflict management [107] and assisting organizations in adoption of anti-bullying policies.[108] Other known strategies for promoting organization-level wellness include healthy nutrition and exercise programs [109] and the reduction or elimination of environmental hazards in the workplace.[22] Thus, an array of interventions have been documented to improve the quality of the work environment, reduce symptoms of stress, and improve worker health- but the vast majority of this research has been conducted with non-9-1-1 TC workers.

2.2.2. Aim 2 Conceptual/Theoretical Framework

Borrowing from the literature on occupational stress, individual stress, and coping response we developed a conceptual framework that describes how a multilevel intervention is expected to effect stress in 9-1-1 TCs (Figure 3). At the individual level, mindfulness training is hypothesized to increase an individual's ability to regulate their emotional response to stressors, whereas the ECC manager-directed organizational level intervention is hypothesized to reduce worksite stressors and increase perceived social support by implementation of targeted strategies and worksite policies.

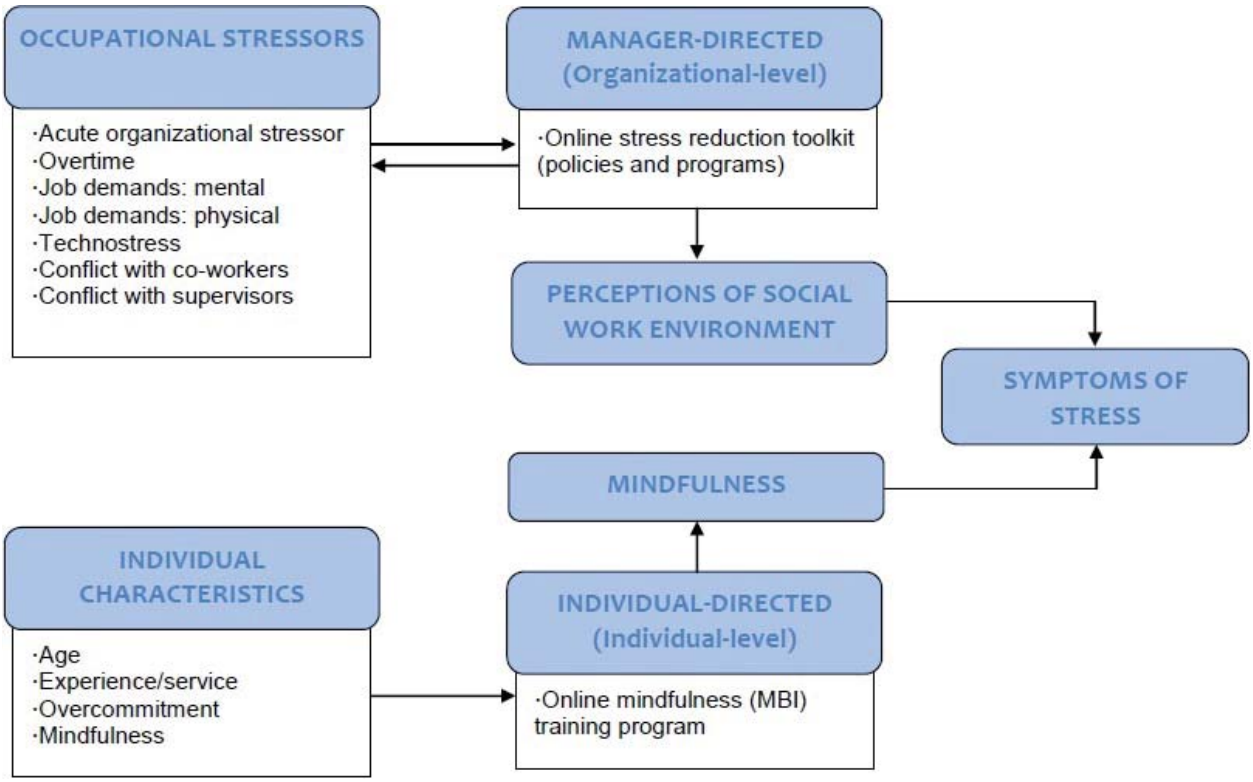

Fig. 3. Aim 2 conceptual framework

2.2.3. Aim 2 Methodology: Procedures and Participants

We used a longitudinal multi-stage study design that consisted of a randomized controlled trial to evaluate the effectiveness of an online mindfulness training in reducing symptoms of stress in 9-1-1 call-center TCs, followed by 3 months access to an online ECC stress reduction activity toolkit for the ECC managers. We enrolled 323 TCs from multiple 9-1-1 ECCs nationwide. As shown in Figure 2, at enrollment TCs completed a baseline stress survey and 323 participants were randomized to either a mindfulness training intervention or wait-list control group. Following the mindfulness training, both the intervention and control groups completed a post-

training survey. Next, managers from all participating ECCs were provided access to the online worker-support Toolkit. After three months of access, all 9-1-1 TCs (training and control groups) were asked to complete a post-toolkit survey. The full study protocol was approved by the Institutional Review Board (IRB) at the University of Washington.

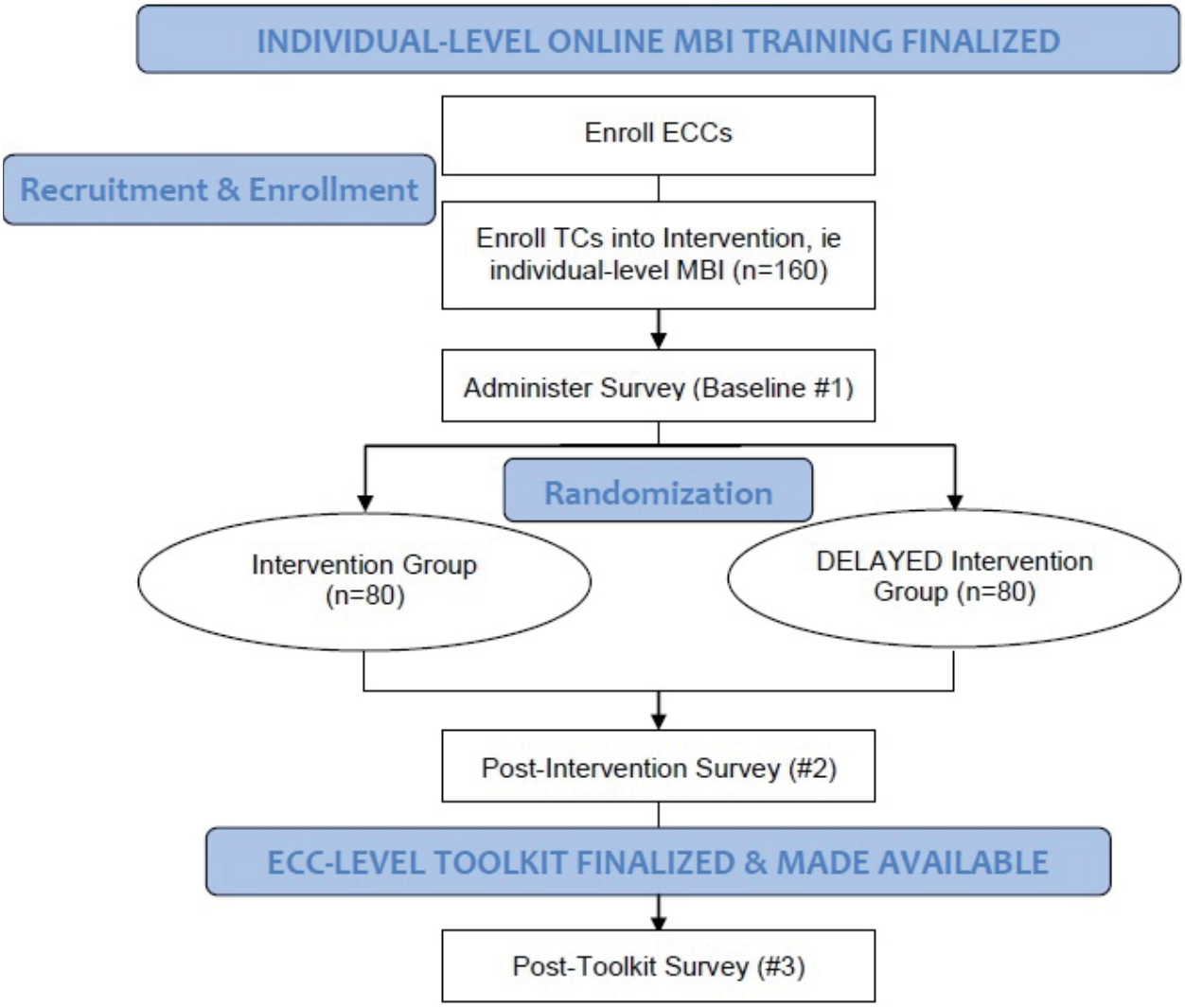

Fig. 4. Aim 2 Study Protocol

Figure 4 illustrates the fact this intervention included 2 distinct interventions, implemented consecutively. As such, the discussion of methodology for each intervention (the methodology-measures, methodology-procedures, methodology-intervention, results, discussion, and conclusion sections) will be separate.

Aim 2, Part 1—Individual-level mindfulness intervention

Aim 2, Part 1—Individual-level mindfulness intervention: Methodology

The online intervention was developed by clinicians and investigators trained in mindfulness-based approaches. The training was adapted from Mindfulness-Based Stress Reduction (MBSR), which is an evidence-based program originally implemented as in-person training.[110-

111] The materials included in the current online program were modified, abbreviated, and tailored to meet the specific constraints and needs of 9-1-1 TCs. Materials incorporated into the intervention provided examples specific to workplace stressors typically encountered by 9-1-1 TCs.

Aim 2, Part 1—Individual-level mindfulness intervention: Procedures
The online mindfulness training (Destress 9-1-1) was comprised of seven modules each completed on a weekly basis. Two emails were sent each week that introduced the weekly theme and provided reminders to practice their mindfulness skills. Completion times for each of these modules ranged from 20 to 30 minutes and included the following: a short video introducing the theme for the week, a brief text describing the theme and activities for the week, an audio-guided meditation exercise, suggestions for brief mindfulness activities that can be performed during the day and at work, and a brief check-in form that participants could use to communicate with study staff regarding the intervention.

Aim 2, Part 1—Individual-level mindfulness intervention: Measures
Stress Symptoms. The cSOSI [65] was used to assess stress symptoms over the past week. As described in the previous section, the cSOSI includes 56 items with eight subscales consisting of 6-9 items each, including depression, anger, muscle tension, cardiopulmonary arousal, sympathetic arousal, neurological/gastrointestinal, cognitive disorganization, and upper respiratory symptoms. Participants respond to items using a 5-point Likert scale ranging from "0 [*never*]" to "4 [*very frequently*]." The cSOSI was originally tested with cancer patients and demonstrated acceptable internal consistency within subscales (α's ranging from .80 to .95). The cSOSI has been used in previous research with 9-1-1 TCs.[34]

Mindfulness. The Mindfulness Scale [112] is a 15-item measure used to assess attentional sensitivity to psychological, somatic, and environmental cues. Response options are on a 6-point Likert scale ranging from "*Almost always*" to "*Almost never*." The MAAS is a widely used measure of mindfulness that has been employed in previous research with 9-1-1 TCs.[34]

Demographics and professional information. Participants reported their age, gender, ethnicity, and years of experience in the 9-1-1 field.

2.2.4 Aim 2, Part 1—Individual-level mindfulness intervention: Results
Enrollment. TC participants included 323 active duty 9-1-1 TCs from across the United States and Canada, with the majority residing in the states of Washington, Kansas, and Missouri. The majority of the participants were between 26 and 35 years of age (33.6%; n = 108) or 36 and 45 years of age (33.0%; *n* = 106). In regards to gender distribution, 81.9% (*n* = 262) identified as female and 18.1% (*n* = 58) as male (3 participants did not specify gender). The majority of the sample identified as European American (71.3%; *n* = 299), with other ethnicities consisting of Black (2.8%; *n* = 9), Native Hawaiian or Pacific Islander (0.6%; *n* = 2), Asian (0.9%; *n* = 3), Native American or Alaskan Native (2.8%; *n* = 9), or Other (3.4%; *n* = 11). Multiple ethnicities were selected by 3.1% (*n* = 10) of participants and 1.8% (*n* = 6) were of Hispanic ethnicity. The majority (>70%) of participants had served as TCs for at least two years; with the following ranges (and percentages) of duty related experience: 2-5 year (23.1%; *n* = 74), 6-10 years (20.9%; *n* = 67) or 11-20 years (30.6%; *n* = 98).

Attrition. Figure 3 provides a CONSORT flow diagram of participant enrollment and retention.

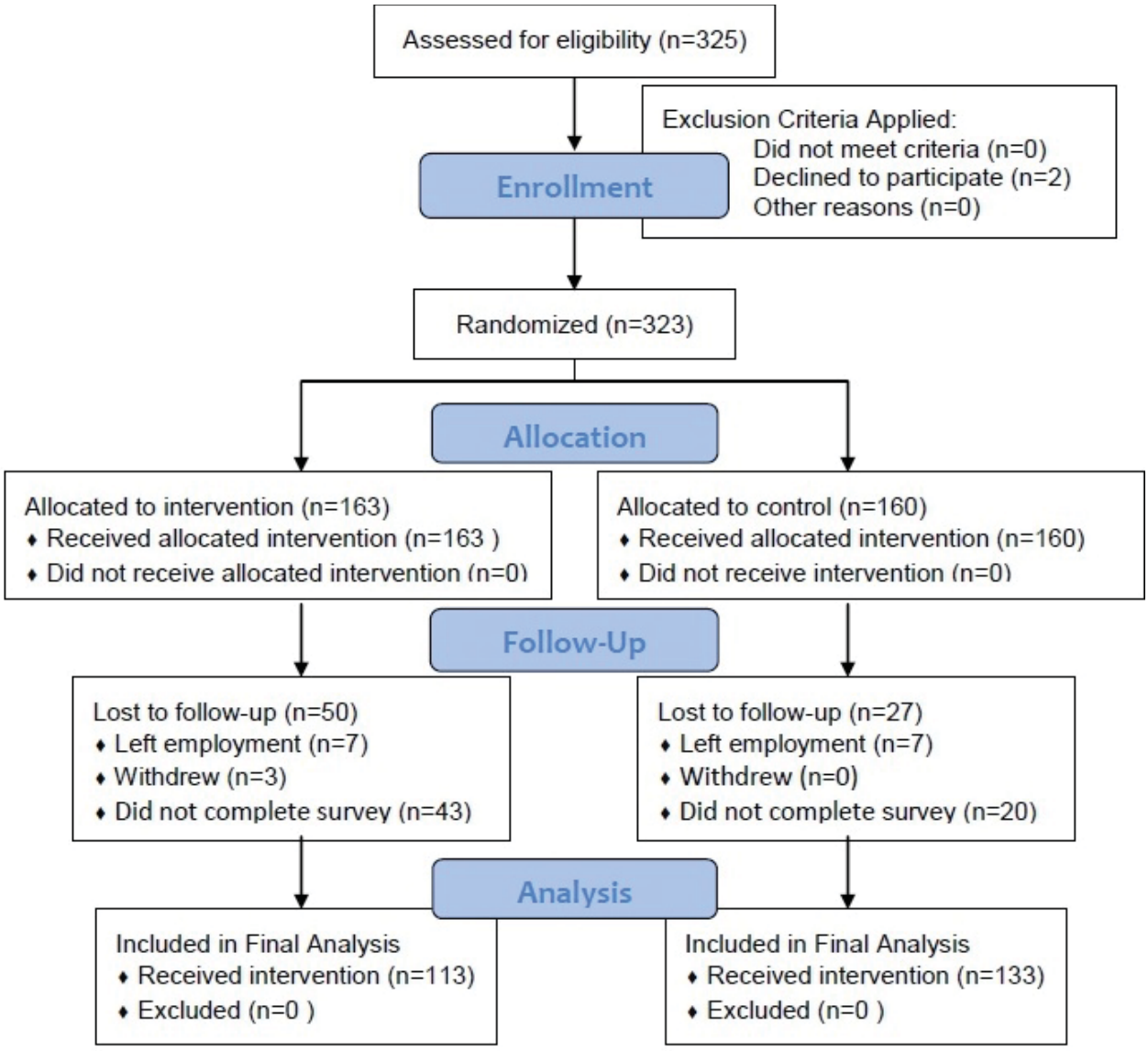

Fig. 5. Aim 2 CONSORT flow diagram

The number of participants who did not complete each survey for the intervention and control groups is shown in Table 7.

Table 7. Non-response by Group and Timepoint

Group	N	Baseline non-response		Post training non-response		Follow-up non-response	
		N	%	N	%	N	%
Control	159	1	0.6	30	18.8	60	37.5
Intervention	160	1	0.6	51	31.7	75	46.6

Considerable differences in rate of survey non-completion were observed between the groups at both the post-training survey (T2) and the three-month follow-up (T3). Survey non-completion was not associated with baseline stress for either group. Within the intervention group, level of participation in the training was associated with survey completion for both the post-training

survey and the three-month follow-up survey, with 78% non-response for participants who completed no trainings, 38% non-response for participants who completed between 1 and 5 of the trainings, and 9% non-response for participants who completed 6 or 7 of the trainings ($p < 0.001$).

Intervention dosage. Of the participants in the intervention group, 40 (24.8%) completed no training sessions, 32 (19.9%) completed between 1 and 5 of the training sessions, and 89 (55.3%) completed 6 or 7 of the training sessions. Reported mean number of days per week on which mindfulness was practiced was 2.1 (*SD* = 1.5, range 0 - 6.8). No statistically significant association was observed between number of training sessions completed and number of days on which mindfulness was practiced for participants who completed at least some training sessions.

Intervention Effects. The primary outcome for the study was participant stress symptoms as measured by the cSOSI scale. Table 8 shows the mean cSOSI scores at baseline (T1), post intervention (T2), and three-month follow-up (T3) for the intervention and control groups. Differences between the intervention group and control group in pre-post changes in cSOSI were statistically significant, with a difference of -10.0 (95% CI: -14.9, -5.2, $p < 0.001$) for change from baseline to post intervention, and a difference of -6.5 (95% CI: -11.9, -1.1, $p = 0.02$) for change from baseline to follow-up.

Table 8. Mean cSOSI Scores by Group and Timepoint

	Control			Intervention			
	n	*M*	*SD*	*n*	*M*	*SD*	*p*-value
Baseline (T1)	159	52.1	27.6	160	57.7	30.4	0.086
Post intervention (T2)	130	54.3	30.5	110	49.7	27.2	0.209
Change from baseline	130	3.1	19.9	110	-7.2	19.2	0.000
Three-month follow-up (T3)	100	52.3	30.5	86	50.7	28.0	0.714
Change from baseline	100	1.9	21.6	86	-5.0	21.2	0.030

To control for the possibility that participants' willingness to complete the training, rather than the effects of the training, was associated with change in stress symptoms we conducted a subgroup analysis comparing participants who completed the training in the intervention group ($n = 88$) with participants in the control group who subsequently completed the training once the training was opened to control group participants (after the follow-up survey) ($n = 38$). This analysis controls for the possibility of an association between completion of the training and change in stress symptoms unrelated to the effects of the training (that is, the possibility that participants who are more likely to complete the training are more likely to show a reduction in stress for reasons other than the training). A difference of -8.1 (95% CI: -15.1, -0.2, $p = 0.025$) for change from baseline (T1) to post-training (T2) was observed, and a difference of -6.7 (95% CI: -15.4, 2.0, $p = 0.131$) was observed for change from baseline (T1) to three-month follow-up (T3) (Table 9).

Table 9. Results of sub-set Analysis							
	Control			Intervention			
	n	*M*	*SD*	*n*	*M*	*SD*	p-value
Baseline (T1)	38	44.4	22.0	88	55.0	24.8	0.020
Post intervention (T2)	36	45.0	23.7	79	47.2	25.1	0.651
Change from baseline	36	-0.2	16.5	79	-8.3	19.7	0.025
Three-month follow-up (T3)	36	44.4	27.5	68	47.2	25.9	0.615
Change from baseline	36	0.1	21.4	68	-6.6	20.8	0.131

Sensitivity analyses. We examined how much bias in non-response could account for the observed effects of training using a multiple imputation simulation. A multivariable model was developed for post-training scores (T2) using baseline measures associated with post-training score or post-training non-response. All variables with statistically significant associations were included in the imputation model. Time 2 scores for participants missing post training data were then imputed using this model with an additional bias term inflating post-training SOSI scores by a fixed amount. The level of bias required to produce no difference in SOSI scores between the groups, and the level of bias required to achieve a non-statistically-significant association between training and SOSI scores with 20% probability were estimated. Ten thousand simulations were used for each level of bias. To achieve a non-statistically-significant association with 20% probability the participants with no post-training cSOSI scores would have to have mean post-training SOSI scores 8 points higher than that predicted by the imputation model. To produce no difference in SOSI scores (so estimated group effect of 0) would require mean post-training SOSI scores to be on average 50 points higher than predicted by the imputation model.

Secondary analysis: Effects of intervention on mindfulness. The mean MAAS scores at baseline, post intervention, and three month follow-up for the intervention and control groups are shown in Table 10. Baseline mindfulness scores were slightly higher in the intervention group than the control group ($p = 0.029$). No statistically significant differences were observed in change in mindfulness between the intervention and control groups at either post intervention survey (T2) or three month follow-up (T3).

Table 10. Mindfulness by Group and Timepoint							
	Control			Intervention			
	n	*M*	*SD*	*n*	*M*	*SD*	*p*-value
Baseline (T1)	159	4.26	0.89	159	4.04	0.90	0.029
Post intervention (T2)	130	4.25	0.88	110	4.14	0.89	0.369
Change from baseline	130	-0.04	0.61	110	0.09	0.65	0.129
Three-month follow-up (T3)	96	4.27	0.96	86	4.15	0.94	0.385
Change from baseline	96	0.00	0.70	86	0.10	0.83	0.381

MAAS score was inversely correlated with stress symptom scores at baseline; that is, participants who had higher (more mindful) MAAS scores had lower baseline SOSI scores ($r = -0.71$, $p < 0.001$). Changes in MAAS score between baseline and post-intervention was also associated with changes in SOSI scores, with participants with greater increases in their MAAS having, on average, greater decreases in their SOSI scores ($r = -0.53$. $p < 0.001$). In the control group, change in MAAS score was negatively associated with baseline MAAS score, with participants having a higher MAAS score more likely to decrease in MAAS between baseline and post intervention than participants having a lower MAAS score. To allow for the possibility

that the higher baseline MAAS scores in the intervention group reduced the apparent effectiveness of the intervention, we also conducted an analysis of the baseline-post intervention change in MAAS scores controlling for the initial baseline score. This analysis did not show any statistically significant effects of intervention in terms of the change in MAAS score or in the slope of the association between baseline MAAS score and post intervention MAAS score.

Secondary analysis: Effects of intervention dose on stress. A secondary analysis was conducted to examine the effect of level of participation on change in stress symptoms within the intervention group. Level of participation was categorized as extensive (6 or 7 sessions completed) versus not extensive (0-5 sessions completed). Participants in the intervention group who completed most sessions (extensive group) seemed to show greater reductions in their SOSI score at both post-training (mean difference -2.7, 95% CI: -11.0, 5.5) and three month follow-up (mean difference = -4.9, 95% CI: 14.4, 4.7) compared to participants who did not; however, these numerical differences were not statistically significant (p = 0.564). Mean number of days mindfulness was practiced was also associated with greater reductions in SOSI scores, with each additional day of training associated with a 1.6 point drop in SOSI at post training (mean difference = -1.6, 95% CI: -4.0, 0.7) and 1.3 point drop at follow up (mean difference -1.3, 95% CI: -3.8, 1.2); however, these associations were not statistically significant (p = 0.362).

2.2.5. Aim 2, Part 1—Individual-level mindfulness intervention: Discussion

This study examined the efficacy of an online mindfulness-based intervention tailored for 9-1-1 TCCs to reduce stress and enhance mindfulness. Results documented significant reductions in stress scores among 9-1-1 TCCs randomized to the intervention group compared to control participants, with effect sizes in the small to moderate range when comparing baseline scores to post-intervention scores (Cohen's d = .34). Results from a three-month follow-up survey indicated that intervention participants continued to show reduced stress scores when compared to baseline, and in comparison to control participants, though the effect size declined to the small range (Cohen's d = .22). Though study attrition was greater among intervention participants, sensitivity analyses revealed that results of the study are robust to the impact of bias introduced by differential attrition across study groups.

2.2.6. Aim 2, Part 1—Individual-level mindfulness intervention: Conclusions and Impacts

This study provided some initial evidence of the efficacy of 9-1-1 Destress, an online mindfulness intervention for 9-1-1 TCCs. Future directions may include a focus on the varying impacts of different dosages of the intervention and use of the training for new hires in preventive efforts. A recent meta-analysis examining the impact of online MBIs in preventive medicine found moderate to large effects in perceived stress and moderate effects in mindfulness among non-clinical samples of volunteers.[113] Whether this intervention could buffer the ill-effects of stress among early career 9-1-1 TCCs and trainees is an important question with significant implications for the 9-1-1 workforce and for public health and safety. Identification of which modules of the training were more impactful may also assist in developing more intensive materials in content areas found to be most beneficial for this population. As a first responder worker population at elevated risk for adverse psychological outcomes such as PTSD and depression [15], examination of whether 9-1-1 Destress can deter the onset or progression of such clinical phenomena is warranted. Prior research has also shown that MBIs can improve overall functioning in other areas important for 9-1-1 TCCs. For example, MBIs have been shown to reduce stress-related working memory impairments in students [114], to enhance occupational functioning in working adults experiencing anxiety [115], and to increase resilience and decrease burnout in police officers.[32] Further exploration of the effects

of this training on such outcomes in 9-1-1 TCCs could shed light on the potential beneficial impacts of MBIs for our very first responders.

Dissemination of the mindfulness intervention: The online training was modified to operate without staff involvement, and the online modules built, with assistance from the NWCPHP's communication and instructional design team. The toolkit (see Figure 5) can be accessed at http://www.nwcphp.org/docs/911-toolkit/stress/index.html

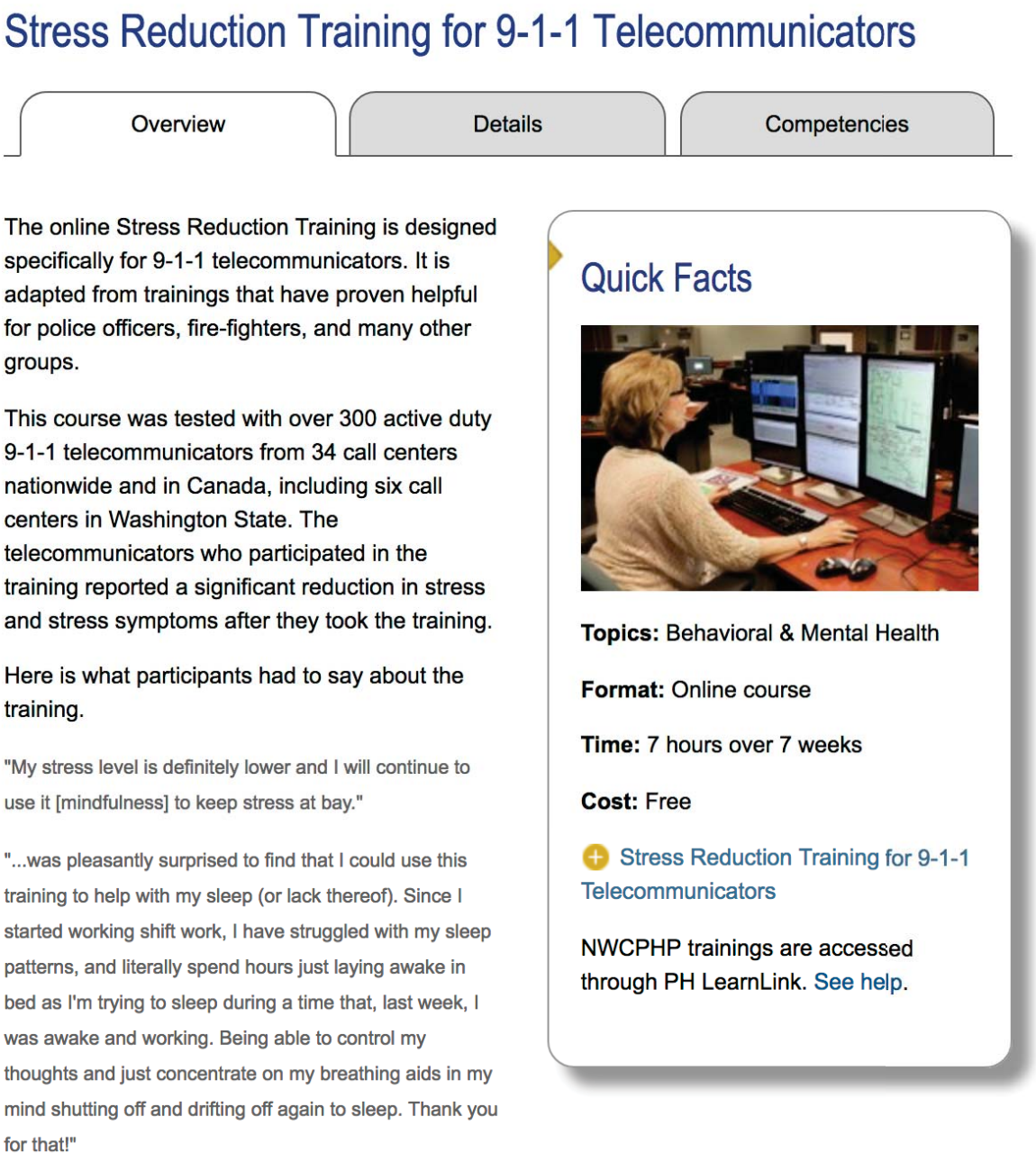

Fig. 5. MBI Training Online

To date (1/25/2019) over 300 participants have started the 7-week training and 86 have completed the training and evaluated the training. Evaluations show participants enjoy the training and feel the training helps them in reducing daily stress. Twenty-nine% of participants reported the training helped them reduce daily stress a moderate amount and 16% reported the training helped them **a lot/great** deal in reducing daily stress.

"*When I feel the added stress coming from a certain call or just in every day life, especially when dealing with my 2 year old daughter, I will take the extra seconds/couple of minutes to practice mindfulness to bring me back to the moment and notice everything about it."*

Aim 2, Part 2—Worker support intervention

2.2.7. Aim 2, Part 2—Worker support intervention: Development of intervention
The worker support intervention to reduce stress in the 9-1-1 ECC environment is in the form of an on-line toolkit, titled: Reducing Stress: A Toolkit for 911 Call Center Managers.

The toolkit was developed using the following steps:
1.Review of academic and grey literature on worksite stress and stress reduction interventions targeting the larger worksite environment. This literature review included review articles on 1) and as well as reports and websites on worksite stress management interventions from government agencies such as CDC and NIOSH and?

2. Survey of ECC managers. The literature identified many worksite stressors, as well as strategies for addressing these, for health care providers generally. In addition, conversations with key stakeholders and observations at ECC allowed us to create a list of stressors we believe are present in ECCs. To help us prioritize workplace stress reduction topics and to ensure the Toolkit would be relevant to our audience we conducted an online survey with 911 ECC managers. One of the PIs, Dr. Meischke, regularly attended the NENA Task Work Overload workgroup, comprised of ten managers from PSAPs nationwide. Dr. Meischke asked several of the workgroup members to send the link to ECCs in their area. A total of 44 responses were received. Table 11 shows the results of the survey. Response categories were: (1) Not at all useful to (5) Very Useful

Table 11. Results of online survey with ECC managers (*n*=44)

Q: Please indicate how useful it will be to include the following content areas in a resilience and stress reduction toolkit for managers of 9-1-1 ECCs.

	Mean
Strategies for conflict management	4.72
Strategies for addressing bullying in 911 ECCs	4.57
Strategies for acknowledging and rewarding TCCs for their work	4.45
Resources for employees (self-help resources for dealing with symptoms of stress	4.39
Strategies for lowering employee stress during the QI feedback process	4.35
Strategies for reducing "technostress" (i.e., stress related to implementation and adoption of new technologies in ECCs)	4.20
Worksite wellness programs (e.g., nutrition/physical activity, flu vaccination etc.)	4.07
Causes of occupational stress (as defined by the research)	4.02
Worksite safety (e.g., noise, ventilation/ergonomics, etc.)	3.70

Conflict and bullying: The literature suggests that workplace conflict and bullying behavior can induce stress. We asked the managers how useful it would be (on the same five-point scale as

Table 1) to include strategies for addressing conflict in the workplace. Results showed that managers thought that strategies to address various types of conflict would be extremely useful. Peer-to-peer conflict (mean of 4.6), conflict between trainer and trainee (mean of 4.4) and conflict between management and staff (4.5). Only 31% of respondents answered that their ECC had a formal policy related to bullying.

Health and Wellness: We asked several questions about health and wellness at the ECC. 65% of managers reported that their ECC had a wellness committee or person who is in charge of employee health or safety. In most cases this was a Human Resource staff member or the managers themselves.

Given the lack of literature on effective strategies to reduce stress that comes with working overtime, we asked the managers what strategies they used to address overtime. Mandatory overtime was identified as a huge source of stress in the literature review, our expert consultants and conversations with 911 personnel. We compiled the list of "tips for how to deal with overtime" and incorporated it into the Toolkit.

3. Expert opinion: Our research team included Dr. Randall Beaton, a research professor emeritus with a joint appointment in the Department of Psychosocial and Community Health and Health Services. Dr. Beaton has decades of experience, as a clinician and researcher, in occupational stress in the fire service. The Toolkit was developed under his guidance and including work and practice from his extensive experience. In addition, Dr. Ann Tu, an Occupational Medicine Fellow, contributed her clinical expertise in development of the content.

2.2.8. Aim 2, Part 2—Worker support intervention: Content of the Toolkit. Based on the information obtained from the literature review; expert opinion and the manager survey, an on-line Toolkit was developed. The toolkit was developed for managers and supervisors to provide them with guidance and support in implementing ECC level interventions which promote the health and well-being of employees. The online toolkit consists of modules on the following topics: 1) an "Overview" or how-to-use this toolkit; 2) introduction to the purpose of the toolkit; 3) worksite wellness (ergonomics, noise in ECCs, stress, treadmills at work, worksite wellness programs, worksite flu vaccine information); 4) conflict (conflict management); 5) bullying (e.g., anti-bullying policies); 6) overtime; 7) technostress; 8) personal stress reduction. The toolkit was designed, and the online modules built, with assistance from the Northwest Center for Public Health Practice's communication and instructional design team. The toolkit is housed on the NWCPHP website and can be accessed by: URL http://www.nwcphp.org/docs/911-toolkit/stress/index.html

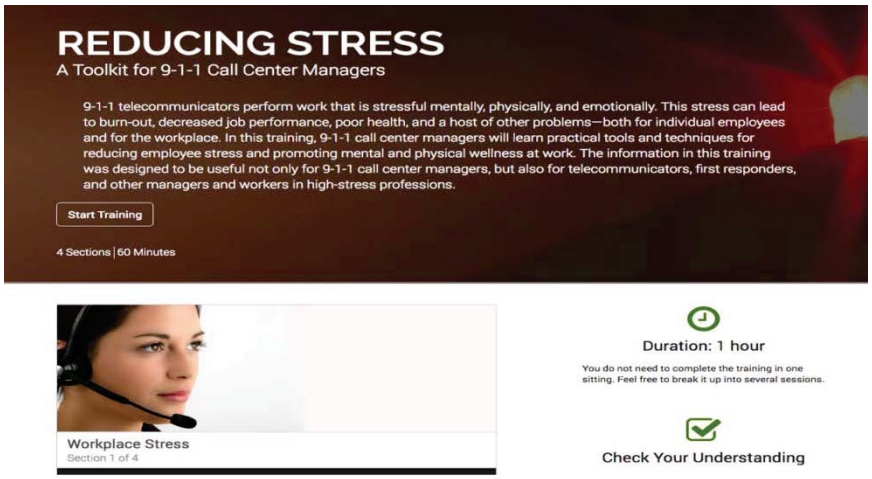

Fig. 6. Worker support intervention: Online screen shot

2.2.9. Aim 2, Part 2—Worker support intervention: Methodology

The worker support intervention was scheduled after the individual-level intervention was completed at participating ECCs. After the second survey (T2) the toolkit was shared with ECC managers. Each enrolled manager was given the link to the toolkit, and were encouraged to share the link with fellow managers and supervisors.

During the 3-months access, to increase engagement with the Toolkit, e-mails were sent to the managers who received the Toolkit link on a bi-monthly basis. These e-mails highlighted particular aspects of the toolkit in the hope that this would trigger interest and engagement. After TCC participants completed the third survey (T3), we surveyed each of the managers who had received the Toolkit link, to assess their engagement and evaluation of the Toolkit.

2.2.10. Aim 2, Part 2—Worker support intervention: Results

Results: Of the 35 managers who received the link to the Toolkit, 19 individuals completed the survey.

Table 12. Worker support intervention evaluation

	Yes (n=19)	Please rate the modules Mean Score (0-100)
Did you access the Toolkit?	12/19 (63%)	
Did you share the link to the Tookit?	3/19 (6%)	
Which of the modules did you access?		
·Worksite Wellness	9/19 (47%)	76
·Conflict Management	7/19 (37%)	75
·Bullying	8/19 (42%)	74
·Overtime	9/19 (47%)	61
·Technostress	6/19 (32%)	67
·Personal resources	8/19 (42%)	81

Note: For each module that respondents reported they had accessed, we asked if they had actually USED any of the tips/activities in their ECCs. Respondents either left the answer blank or reported they had not used the tips/activities from the modules. Two respondents reported they had used some of the personal resources.

One respondent said: “I found the Toolkit had very useful reference guides such as conflict, unplugging, breaks etc.” Another respondent said: “ I plan on exploring the toolkit, but have had very little time to look at it thus far”

2.2.11. Aim 2, Part 2—Worker support intervention: Discussion

Given the lack of engagement with the Toolkit we did not evaluate the impact on perceived social support as measured in the three surveys that were completed by the individual TCCs. It was surprising to find that even though the Toolkit was designed with input from 9-1-1 ECC managers, uptake of the Toolkit was low. Anecdotally, managers told us they did not have time to engage with the toolkit. This was disappointing but interesting as these very managers reached out to our research team in the first place with the request to assist them in managing occupational stress at their ECCs. More research needs to be conducted to find out how worker support tools can be developed for use by worksite leadership.

2.2.12. Aim 2, Part 2—Worker support intervention: Conclusion

The Toolkit was developed based on input from our stakeholders. The on-line format was also suggested by our audience. However, the lack of engagement with the Toolkit suggests that more is needed to engage the audience. After the study ended we turned the Toolkit into an on-line training which resulted in a much higher uptake than we experienced during our study period. In the 9-1-1 industry, there seems to be a desire for low/no cost continuing education opportunities and development of trainings that can count toward that goal might facilitate dissemination. More research needs to be conducted to find out how on-line tools can be marketed to increase uptake.

Dissemination of the Worker support intervention Toolkit: Managers of ECCs are extremely busy and even HR personnel at ECCs have little time to spare to engage with a fairly “meaty” on-line Toolkit. Based on our experience with the very high rates of engagement with the other on-line training (the 7 week mindfulness intervention) we decided to transform the manager Toolkit to a formal training so managers can obtain continuing education credit for working through the Toolkit and answering quizzes throughout. After the last quiz has been taken the managers will receive X hours of continuing education credit from the Washington State Criminal Justice Commission. The training includes an evaluation and we will compile data of respondents for reporting purposes and for development of targeted marketing strategies.

The toolkit is housed on the NWCPHP website and can be accessed by at http://www.nwcphp.org/docs/911-toolkit/stress/index.html

ADDENDUM: Aim 2, Part 2— Worker support intervention: Current Participation and Evaluation of the "Reducing Stress: A Toolkit for 9-1-1 Call Center Managers"

As of 02/6/2019 approximately 162 users have accessed the toolkit (Table 13). Of these, 106 completed the evaluation and 113 have received certificates of completion.

Table 13. TOOLKIT EVALUATIONS (as of 2/6/2019)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
I was satisfied with this training overall.	3.77% (4)	0.94% (1)	10.38% (11)	62.26% (66)	22.64% (24)	106
My understanding of the subject matter	3.77%	2.83%	21.70%	55.66%	16.04%	

has improved as a result of having participated in this training.	(4)	(3)	(23)	(59)	(17)	106
I have identified actions I will take to apply information I learned from this training in my work.	2.83% (3)	3.77% (4)	16.04% (17)	56.60% (60)	20.75% (22)	106
The information was presented in ways I could clearly understand.	1.89% (2)	1.89% (2)	4.72% (5)	61.32% (65)	30.19% (32)	106
The course was well organized.	1.89% (2)	3.77% (4)	7.55% (8)	58.49% (62)	28.30% (30)	106
I will recommend this course to other professionals.	2.88% (3)	1.92% (2)	17.31% (18)	47.12% (49)	30.77% (32)	104

When asked, “to what extent will you apply the knowledge and skills acquired through this training program in your work?” 33.02% said *sometimes*; 45.28% said *usually*; and 19.81% said *always*.

When asked, to what extent did their confidence, related to the nine learning objectives, change as a result of participating in the course, 42.86% - 56.19% of users reported being *somewhat more confident*; and 18.10% - 25.71% reported being *much more confident*.

2.3. Aim 3

Specific Aim 3: Build an ABM tool of 9-1-1 call centers to explore strategies to improve 9-1-1 telecommunicator workforce training and smooth transitions to future call center innovations

2.3.1. Aim 3 Background

Aim 3 was designed to demonstrate our understanding of workflow and task protocols in the call center environment by building an agent-based model (ABM) tool for testing organizational staffing and management strategies that might buffer the impacts of call center technological changes on its workforce. ABM is a computational modeling technique used to understand and explore social phenomena, both the dynamics of the process itself and the end state of interactions and processes.[116] This modeling provides a method for visualizing, analyzing, and informing complex dynamic systems in which agents—individuals, organizations, work places, governments, or any other entity of interest—are assigned a specified set of characteristics and, within the model, interact with each other and with their environment according to predefined rules. Creating a computer simulation of a complex system prior to introducing workflow or other changes in the environment can be useful for "forecasting" impacts and unexpected effects of an intervention or change, as well as allow experimentation with alternative scenarios at minimal cost to the organization.[116]

2.3.2. Aim 1 Conceptual/Theoretical Framework

ABM is understood to be a bottom-up approach, in that modeling allows for the emergence of macro-level (organizational) phenomena from micro-level (individual) behavior and interactions. As applied to the implementation of NG911 technologies in call centers, the overall focus of Aim 3 was to build a model that demonstrated our understanding of the effects of the new technologies deployment on Aim 1 outcomes of workforce retention and performance and Aim 2 outcomes regarding training in the 9-1-1 call center environment. The long-term objective is to design and develop an ABM tool to support investigations of or experimentation with call center environment modifications (for example, changes to shift structure) in order to forecast the effects of those changes on call takers, managers and the overall call center environment.

2.3.3. Aim 3 Methodology

Work on Aim 3 was conducted over 3 phases—Preparation, Testing and Implementation—with model development based on a hybrid framework of two methods for systematic and standardized organization of data requirements and collection:

- The Delineate, Structure, and Gather (DSG) Framework: A method for determining data needs, how those data needs fit into relevant categories, and how to organize model elements.[117]
- The Modelling Agent systems based on Institutional Analysis (MIAI) Framework: An ethnographic approach that specifies data collection protocols, organization, and incorporation into the model.[118]

Aim 3 methodology was further informed by the JD-R model.[55,58,60] In addition, as with any complex model or simulation development, the process is iterative with a number of recursive steps as visualized in Figure 7 below.

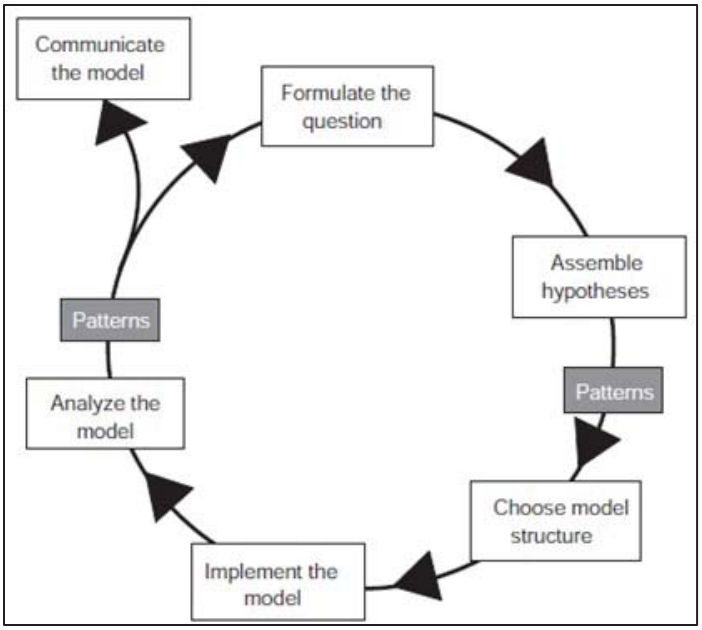

Fig. 7. ABM development methodology

Preparation Phase. The first phase focused on developing the overall model conceptual framework; delineating well-defined research questions for modelling; identifying anticipated gaps in Aim 1 and 2 data collection with respect to the Aim 3 model and reviewing the literature to obtain supplemental data for integration as needed; and exploring available tools for modeling to ensure the selected ABMS tool is most appropriate for the project.

Testing Phase. The testing phase focused on preliminary model construction based on the selected model type and conceptual framework. This iterative development phase included repeated steps setting up, executing and verifying that the model is an adequate representation of the real world system. Significant effort was invested in debugging, running and reworking the model to address problems identified, and revising parameters. Throughout this phase the ABM was periodically reviewed by the project team to determine whether the ABM was achieving its goals and answering the questions it was built to answer.

Due to the complexity of the model the model was built around the MASON (MultiAgent Simulation) environment[119] in the Java programming language, requiring the java runtime engine version 18.0 or higher to run.[120] Quantitative elements of the model were based on analyses of data collected from Aims 1 and 2 which was further complicated due to the delayed deployment of text 2-911 and need to stagger data collection.

Implementation Phase. This phase involves preparing the model for operation and developing documentation for training users and, at the time of preparing this report, is currently underway. We are planning to communicate overall results of the project by running scenarios of interest and specified questions using the model and obtaining feedback from call center managers.

2.3.4. Aim 3 Results

The conceptual basis for the model was developed during the *Preparation Phase* through literature scan of relevant conceptual models of occupational stress. Structural elements of the model were developed on the basis of the conceptual model and the physical processes of

handling calls within the call center. A list of potential emergent elements for inclusion in the model was developed based on: informational interviews with call center managers; content scan of online 9-1-1 call center discussion boards; and a literature scan of relevant ABMs. Elements from this list were prioritized based on the likelihood of providing useful insights to call centers, availability of conceptual models which could be used as a basis for ABMs, and ability to collect data relevant to estimating parameters for inclusion in an ABM that included the specified element. Figure 8 provides a high-level view of the ABM structure.

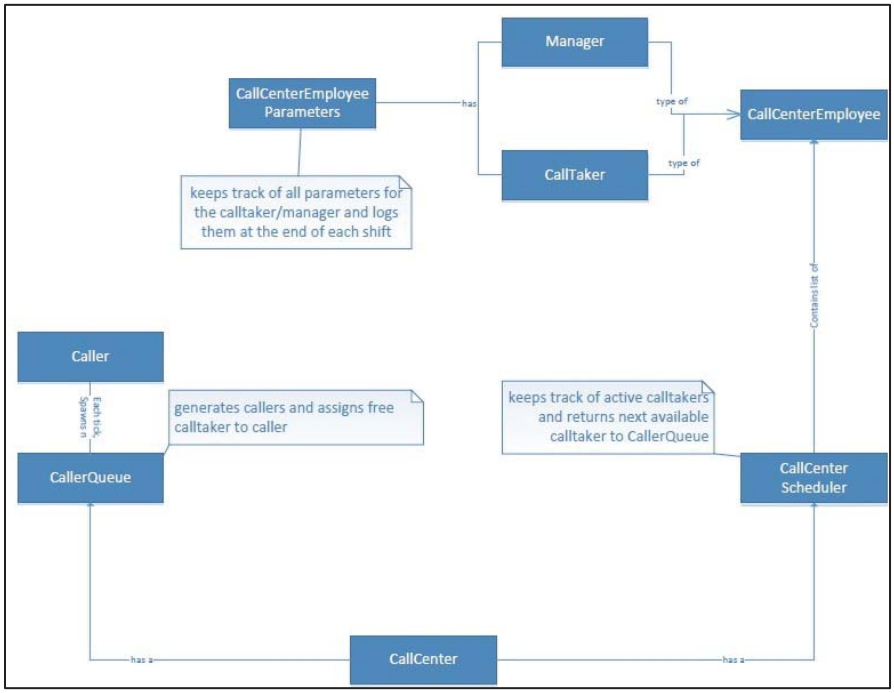

Fig. 8. Minimalistic 9-1-1 call center ABM structure

The conceptual model was developed based on the JD-R model of occupational stress. A two-factor model for demand was selected, with psychological related demands and task processing related demands. Task processing was included as this the introduction of new NG911 technologies directly impacts the tasks that a call receiver must process. Psychological related demands were included to allow for the effect of anticipation of the effects of technology change and to allow for stress itself to act as a job demand by acting as an emotional demand. Both sets of demands contribute to occupational stress in the model.

During the *Preparation Phase*, a set of research questions was developed to drive specification of the ABM model. These questions were prioritized first based on research priorities and second based on development effort required. The objective was to implement a model that was flexible enough to allow for answering each of these questions given collection and analysis of sufficient observational data. The final set of research questions are listed in Table 14.

Table 14. Master Set of Research Questions for ABM
1. What is the relationship between method of training for technological change and stress associated with NG911 technologies?
2. What is the relative impact of general changes in technologies?
3. What is the impact of different technologies on information gathering such as upgrade /

downgrade probabilities?
4. What is the impact of different technologies on call performance as measured by time to dispatch, etc.?
5. What characteristics of a technology change (NG911, new CAD system, etc) can predict change in stress (raising/lowering)?
6. What characteristics of a technology change can predict change in performance?
7. What is the relationship between the characteristics of individual calls (for ex, a few highly stressful calls vs numerous moderately stressful calls) and long-term stress?
8. Does the amount of emotional content in a call impact CRs? (texting is less emotionally impactful than video?)
9. What is the relationship between call volume and stress?
10. What is the relationship between protocols for assigning overtime (OT) and attrition/turnover intention?
11. What is the relationship between protocols for assigning OT and sick leave (illness- and work-related)?
12. What is the relationship between protocols for assigning OT and stress?
13. What is the relationship between protocols for assigning OT and performance?
14. What is the relationship between protocols for shift structure (ex, 8- vs 12-hr shifts) and attrition/ turnover intention?
15. What is the relationship between protocols for shift structure and sick leave?
16. What is the relationship between protocols for shift structure and stress?
17. What is the relationship between protocols for shift structure and performance?
18. What is the relative impact of general changes in information tasks?
19. What is the relative impact of possible exposure to negative stimuli from new information tasks?
20. How might manager training (and what kind?) improve perceptions and activation of manager support (resource) among call takers?
21. Do exercise or healthy eating incentivizing programs enhance wellness in the call center?

The conceptual model was implemented in the *Testing Phase* as a hierarchical two-factor model, i.e., a model consisting of interactions between psychological-related demands occurring on the basis of work shift (so updating agent parameters occur once per shift) and task processing interactions on the basis of individual calls (so task processing elements are updated once per task, with multiple tasks per shift). Task processing elements are linked to the psychological-related demand parameters which can be updated on the basis of aggregate call processing results, aggregated over each shift. Agents represent individual call center workers, but interactions between agents are not directly modeled; instead agent psychological-related demand parameters are updated on the basis of shift and call center level aggregate parameters. For example, psychological demand parameters for individual agents such as co-worker support may be adjusted based on shift level aggregate stress levels at the call center.

The task processing model was based on standard queuing theory, with two types of interactions with customers (9-1-1 callers) allowed for, representing standard interactions (i.e., telephone calls) and interactions based on a new technology (for example, text-2-911). The psychological-related demands model can be unlinked from the task processing model to allow for the psychological-related demands model to be run without regard to call center task handling performance. This latter point is important as measurements of call center task processing performance can be challenging to obtain.

The following elements were implemented and tested in the task processing model during the *Testing Phase*:

- Rate of incoming tasks to call center
- Relative proportion of incoming tasks using new technology
- Distribution of task processing times for each technology
- Distribution of psychological intensity of task
- Probability of caller ending task prior to processing
- Influence of caller wait time on psychological intensity of task

The task processing model was implemented directly in Java, with structural elements of the task queue fixed and starting parameters read from a configuration file. The psychological-related demands model was implemented using a flexible spreadsheet driven approach to specify many of the structural relationships between the psychological demand parameters, as well as the starting parameters for all elements. The fixed structural elements of the psychological-related demands model were focused on assignment of hiring of new employees, assignment of overtime and introduction of new technology. Several alternative models for assigning overtime based on seniority were included as options which can be specified in the configuration file.

Development of specific fixed structural elements of the model and methods of updating parameters were driven by the master set of research questions in Table Aim3.1 that the model was developed to address. Examination of various specific hypotheses around how psychological demands relate, for example, to attrition and use of sick leave can be conducted by modifying the control spreadsheet to specify how the psychological demand elements interact without requiring reprogramming of the underlying model.

As stated, due to the delayed deployment of text 2-911 and need to stagger data collection, while development of the model proceeded as planned, adjustments were made iteratively to incorporate quantitative analyses of Aims 1 and 2 data.

The effects of deployment of the text 2-911 observed in Aim 1 validate the use of the JD-R model for the psychological demands portion of the model. In particular the model demonstrates that new technologies can impact the workplace without directly impacting employee stress or productivity through the impact on work satisfaction, which in turn has impacts on employee attrition (Master Research Question 2). Based on the data collected in aims 1 and 2 the model can be used to measure general effects of changes in workplace protocols (Master Research Questions 10 through 17).

Aim 3 is currently in the final *Implementation Phase* and is preparing the model for wider testing and validation and final documentation. The Aim 3 ABM has been built using open-source code and components. To ensure its widest dissemination while protecting integrity of the source code, all ABM code and documentation/README files will be deposited in Bitbucket[1], a web-based version control repository hosting system for source code and development projects. Access to Bitbucket is free and users adhere to best practices in software development and documentation to ensure version control is maintained.

2.3.5. Aim 3 Discussion

[1] bitbucket.org

Successful model building requires a series of steps beginning with specific questions from which a conceptual model is developed that supports decision-making regarding elements and process to include or ignore. With a system as complex as a 9-1-1 call center however, the questions may include too many degrees of freedom. However, by basing our conceptual model on the JD-R model of occupational stress we were able to limit the ABM to a two-factor model for demand (psychological-related and task processing). This enabled us to use observed patterns for model design specifically derived from observed patterns in the data collected in Aims 1 and 2.

During implementation of the ABM it was apparent that direct measurement of many attributes in the model is a challenge, which in turn makes development of models tailored for individual call centers to forecast the effects of changes in call center processes (whether technology-related or not) also challenging. The call processing module of the model requires estimates of call processing parameters, which requires standardized access to call processing logs and subsequent statistical analysis of the call processing data. Similarly, the psychological demands module uses parameters which, to be robust, requires collecting data beyond what Aim 1 collected from call center employees. Gathering this data and analyzing it prior to using an ABM for forecasting will require substantial upfront work by managers and a potential burden on call takers for the ABM to more precisely provide specific predictions of impacts of new technologies in any individual 9-1-1 call center.

In addition, tension between model simplicity and model realism is a commonly cited ABM challenge.[121] Finding a balance between simplified representations of reality as illustrated in Fig. 8 and incorporating sufficient complex elements to provide new insights requires extensive expertise as well as time to run multiple what-if scenarios and simulations so ABM elements and parameterizations can be adjusted and greater complexity can be introduced. However, a significant aspect of Aim 3 was structuring and population of the ABM based on empiric data collected specifically to inform the model. The majority of ABMs are developed using data sources extrapolated from the literature to set parameter values, as opposed to using data collected from the target population and specifically for development of the ABM. Most model developers rely on these proxy values because they are not equipped to collect relevant data or lack sufficient domain expertise to articulate clear relationships and/or behavioral properties of agents and/or their environment. These ABM specifications then are based on data that are subject to confounding as well as uncertain transportability that reduces the model's utility for exploring causal mechanisms, social network influences and their implications.[122] In addition, lack of empiric data limits validation of an ABM, thus confidence in the results generated by the model.[123] By utilizing original data collected by Aims 1 and 2, supplemented by values taken from the literature as needed, we are establishing a new "best practice" for data collection and developing models that will ensure the ABM's potential benefit, as well as ease of use for both technical and non-technical users.

2.3.6. Aim 3 Conclusions and Impacts

This work is a proof-of-concept demonstration that ABM can be utilized to understand the cumulative impact of new technologies on workplace psychological demands. In particular it validates the use of the JD-R framework for understanding how new technology impacts the workforce.

Due to heterogeneity of call center environments and the logistics of collecting detailed data from within the call center, the use of ABMs as a tool to forecast impact of technology changes at a specific call center by managers at the call center may not be feasible. Rather we see two areas of impact from this work. The first is in educating call center managers on the implications

of the JD-R model on the call center workforce. While not feasible for forecasting changes at specific call centers, the model can be used to show how aspects of the JD-R model relate to workforce stress, satisfaction and attrition. The second area is in conducting research on understanding general changes in call center workforce characteristics (stress, work satisfaction, attrition and performance) from implementation of future technologies by the 911 system.

Because the model separates out the impact of stress from the impact of work satisfaction, the model demonstrates that different new technologies may have different impacts on the 911 workforce. Technology changes that result in higher psychological demands (such as seeing images and video) may be expected to impact stress and well-being of 911 call center employees but have less impact on work satisfaction and attrition, while technologies that reduce the ability of 911 call center employees to choose the most appropriate response would be expected to result in lower work satisfaction and increase attrition. We plan to use the model to conduct future work in two specific areas: (1) using the model to understand the effects of specific new technologies on the workforce, specifically on impacts of the technologies (specifically effects of attributes of technology – for example, workload effects, psychological demands and training requirements), on psychological demands and (2) examine the effects of technologies on call processing level performance.

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Publications

Baseman J, Revere D, Painter I, Stangenes S, Lilly M, Beaton R, Calhoun R, Meischke H: [2018] Impact of New Technologies on Stress, Attrition and Well-being in Emergency Call Centers: the NextGeneration 9-1-1 Study Protocol. BMC Public Health 18:597.

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Manuscripts currently under Review

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Lilly M, Calhoun R, Painter I, Beaton R, Stangenes S, Revere D, Baseman J, Meischke H: [2019] Destress 9-1-1: Efficacy of an Online Mindfulness-based Intervention in Reducing Stress for 9-1-1 Telecommunicators. Occupational and Environmental Medicine.

Meischke H, Beaton R, Lilly M, Tu A, Revere D: [2019] A Revised Ecological Model of Occupational Stress: Applications to 9-1-1 Telecommunicators. Workplace Health Safety.

Manuscripts in Process

"Call if you can, text if you can't"? The Impact of Emergent Communication Technologies on Emergency Call Centers.

PHS Inclusion Enrollment Report

OMB Number: 0925-0001 and 0925-0002
Expiration Date: 10/31/2018

This report format should NOT be used for collecting data from study participants.

***Study Title (must be unique):** Multi-tasking to Hyper-tasking: Investigating the Impact of Next Generation 911

* Delayed Onset Study? ☐ Yes ☒ No

If study is not delayed onset, the following selections are required:

Enrollment Type ☐ Planned ☒ Cumulative (Actual)

Using an Existing Dataset or Resource ☒ Yes ☐ No

Enrollment Location ☒ Domestic ☐ Foreign

Clinical Trial ☒ Yes ☐ No **NIH-Defined Phase III Clinical Trial** ☐ Yes ☒ No

Comments:

Racial Categories	Ethnic Categories									
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			Total
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	4	3	0	1	0	0	0	0	0	8
Asian	6	0	0	0	0	0	0	0	0	6
Native Hawaiian or Other Pacific Islander	5	0	0	0	0	0	0	0	0	5
Black or African American	11	2	0	0	0	0	0	0	0	13
White	450	139	1	10	1	1	6	1	0	609
More than One Race	9	2	0	1	1	0	0	0	0	13
Unknown or Not Reported	11	2	0	2	1	0	1	1	0	18
Total	496	148	1	14	3	1	7	2	0	672

To ensure proper performance, please save frequently.

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

All methods and data collection instruments used to support this project have been made freely available to other investigators through our publication of study protocols manuscripts in BMC Public Health, an open-access journal, or may be available by request from the corresponding PI.

Aim 1 study protocols and supplemental materials may be accessed at bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5510-x

Aim 2 study protocols and supplemental materials may be accessed at bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5471-0

Aim 3 ABM open-source code and documentation/README files are available through Bitbucket, bitbucket.org, a web-based version control repository hosting system for source code and development projects

Destress 9-1-1, the stress reduction training for 9-1-1 telecommunicators, comprised of seven online modules, has been made freely available at www.nwcphp.org/training/opportunities/online-courses/stress-reduction-training-for-9-1-1-telecommunicators.

The ECC Manager Toolkit containing resources and training on worksite wellness (ergonomics, noise in call centers, stress, treadmills at work, worksite wellness programs, worksite flu vaccine information), conflict management, technostress, and personal stress reduction, among other topics, has been made freely available at www.nwcphp.org/docs/911-toolkit/stress/index.html.

The data that support the findings of this study are available from the corresponding PI upon reasonable request.