

**MEDICAL EMERGENCY TEAM CALLS IN RADIOLOGY: IN-PATIENT
CHARACTERISTICS AND OUTCOMES**

by

Lora Kay Ott

BSN, Indiana University of Pennsylvania, 1981

MSN, University of Pittsburgh, 1995

Submitted to the Graduate Faculty of
School of Nursing in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

University of Pittsburgh

2011

UNIVERSITY OF PITTSBURGH

School of Nursing

This dissertation was presented

by

Lora Kay Ott

It was defended on

July 14, 2011

and approved by

Dr. Michael Pinsky, MD, School of Medicine, University of Pittsburgh

Dr. Leslie Hoffman, PhD, School of Nursing, University of Pittsburgh

Dr. Dianxu Ren, MD, School of Nursing, University of Pittsburgh

Dr. Sean P. Clarke, RN, PhD, FAAN, School of Nursing, University of Toronto

Dr. Sunday Clark, ScD, School of Medicine, University of Pittsburgh

Dissertation Advisor: Dr. Marilyn Hravnak, RN, PhD, University of Pittsburgh

Copyright © by Lora Kay Ott

2011

MEDICAL EMERGENCY TEAM CALLS IN RADIOLOGY: IN-PATIENT
CHARACTERISTICS AND OUTCOMES

Lora Kay Ott, PhD

University of Pittsburgh, 2011

Background: In-patients treated in the Radiology Department (RD) represent a wide range of acuity, and when instability occurs, Medical Emergency Treatment team (MET) activation is one method of rescue intervention. Extensive literature describes MET activations on hospital units, but little is known about MET activation in the RD (MET-RD).

Objective: To identify characteristics of patients experiencing a MET-RD, the relationship between characteristics and outcomes, and to determine the difference in MET event rates between the hospital ward (MET-W) and MET-RD.

Methods: Retrospective review of 111 MET-RD calls (5/2008-4/2010) identifying the patient characteristics before RD-transport and during RD care; then comparing patient characteristics to good and poor post MET-RD outcomes. Additionally, comparing the event rates of all MET-W and MET-RD for 2009.

Main Results: The majority of MET-RD patients had a Charlson Comorbidity Index ≥ 4 and were from non-ICU units (60%), and 43% of MET-RD occurred on admission day one. MET-RD patients commonly arrived with nasal cannula O₂ (48%), recent tachypnea (28%) and tachycardia (34%), and 16% fulfilled MET vital sign call criteria within the 12 hours before MET-RD. MET etiologies were cardiac (41%), respiratory (29%) or neurologic (25%), and occurred most frequently during CT (44%) and MRI (22%). Post MET-RD, 70% of patients required a higher care level. Death (25%), was significantly associated with cardiovascular support prior to RD ($p=.02$), a requirement for RD monitoring ($p=.02$) or heightened RD surveillance ($p=.04$). The MET-RD event rate was higher than MET-W (0.42 v. 0.31

events/hour/1000 admissions) but not statistically different ($p=0.73$). Event rate analysis for the combined RD specialty modalities (minus general x-ray) revealed a significantly higher average RD specialty modality event rate when compared to MET-W (0.76 v. 0.31, $p=.007$).

Conclusions: The majority of MET-RD patients came from non-ICU units, with comorbidities and documented alterations in vital signs prior to the RD. Heightened surveillance and physiologic support in the RD suggests caregiver awareness of patient risk. Higher event rates were noted in RD specialty modalities, suggesting the need for increased surveillance needs in these areas.

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
1.1	SPECIFIC AIMS	3
1.1.1	Definition of Terms.....	4
1.2	CURRENT BACKGROUND AND REVIEW OF LITERATURE	5
1.2.1	FTR: Concept & Nursing Implications	6
1.2.2	FTR & Medical Emergency Treatment (MET) Teams	8
1.2.3	FTR & Surveillance.....	10
1.2.4	FTR & the RD.....	12
1.3	CONCEPTUAL FRAMEWORK.....	13
1.4	SIGNIFICANCE OF RESEARCH STUDY FOR NURSING.....	15
1.5	PRELIMINARY STUDIES	16
2.0	RESEARCH DESIGN AND METHODS	18
2.1	STUDY DESIGN	18
2.1.1	Research Setting	19
2.2	STUDY POPULATION & RECRUITMENT	19
2.2.1	Subject Inclusion & Exclusion Criteria.....	20
2.3	STUDY VARIABLES	20
2.3.1	Non-modifiable patient characteristics.....	20

2.3.2	Modifiable patient characteristics.....	21
2.3.3	MET activation criteria for UPMC Presbyterian Hospital.....	22
2.3.4	Modifiable surveillance characteristic.....	23
2.3.5	Patient Outcomes/FTR.....	23
2.3.6	Incidence of MET-RD and Incidence of in-patient MET	24
2.3.7	Study Variables and Databases	25
2.4	DATA COLLECTION AND MANAGEMENT	26
2.4.1	Data Collection and Management: Specific Aims 1 & 2.....	26
2.4.2	Data Collection and Management: Specific Aim 3.....	27
2.4.3	Data Management.....	30
3.0	STATISTICAL MANAGEMENT PLAN.....	32
3.1	DESCRIPTIVE STATISTICS	32
3.2	DATA SCREENING PROCEDURES.....	32
3.3	SPECIFIC AIM 1	34
3.4	SPECIFIC AIM 2	35
3.5	SPECIFIC AIM 3	36
3.6	SAMPLE SIZE.....	37
4.0	HUMAN SUBJECT RESEARCH.....	38
4.1	RESPONSIBLE CONDUCT OF RESEARCH	38
4.2	PROTECTION OF HUMAN SUBJECTS	39
4.3	WOMEN, MINORITY AND CHILDREN INCLUSION IN RESEARCH. 40	
4.3.1	Inclusion of Women and Minorities	40
4.3.2	Inclusion of Children.....	40

4.4	DATA SAFETY AND MONITORING PLAN	40
5.0	RESEARCH RESULTS AND DISCUSSION: SPECIFIC AIMS 1&2	41
5.1	RESULTS FOR SPECIFIC AIMS 1 & 2	41
5.2	DISCUSSION SPECIFIC AIMS 1 & 2	47
5.3	LIMITATIONS SPECIFIC AIMS 1 & 2.....	52
5.4	CONCLUSIONS SPECIFIC AIMS 1 & 2.....	52
6.0	RESEARCH RESULTS AND DISCUSSION: SPECIFIC AIM 3.....	54
6.1	RESULTS SPECIFIC AIM 3	54
6.2	DISCUSSION SPECIFIC AIM 3	55
6.3	LIMITATIONS SPECIFIC AIM 3.....	60
6.4	CONCLUSIONS SPECIFIC AIM 3	61
6.5	FINAL IMPLICATIONS.....	61
	APPENDIX A - QUALITY IMPROVEMENT APPROVAL	63
	APPENDIX B - IRB APPROVAL LETTER	69
	APPENDIX C - NIH NINR FUNDING LETTER.....	72
	BIBLIOGRAPHY	79

LIST OF TABLES

Table 1. Study Variables and Databases.....	25
Table 2. The total sample demographic and care requirement prior to RD and outcomes.....	46
Table 3. The total sample demographic and care requirement intra-RD and outcomes.....	47
Table 4. MET-RD, MET-W, admissions, incidence and event rates	58
Table 5. MET-RD, admission, incidence and event rates per Radiology modality	59

LIST OF FIGURES

Figure 1. Hospital and Patient Level Factors Contributing to Failure to Rescue	14
Figure 2. Equations to calculate incidence and event rates of MET-RD and MET-W	30
Figure 3. MET-RD calls according to day of the week and time of day.	44
Figure 4. Patient outcomes post MET-RD.....	45

1.0 INTRODUCTION

Hospitalized patients who require diagnostic procedures in the Radiology Department (RD) range from “stable” patients admitted for elective surgery to highly unstable critically-ill patients who require a high level of technologic monitoring and physiologic support, including mechanical ventilation and hemodynamic assistance. Nurses providing care in the RD are challenged by the high acuity of the conditions of many of the patients served by this unit, their complex needs, and the constant surveillance required to detect physiologic changes that signal the need for rescue interventions should instability occur. Failure-to-Rescue (FTR) is defined as death that occurs after a hospitalized patient develops a complication (a complication being a condition that was not present on admission) (Silber, Williams, Krakauer, & Schwartz, 1992). Prior studies have identified patient, nurse, and organizational characteristics that contribute to FTR on clinical units (Needleman & Buerhaus, 2002; Aiken, Sloane, Lake, Sochalski, & Weber 1999; Aiken, Clarke, & Sloane, 2002; Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Aiken, Clarke, Sloane, Sochalski, & Silber, 2008; Clarke & Aiken, 2003). Notably, patient instability always precedes FTR (Prosser, et al. 2007; Chein, Lu, Wo, & Shoemaker, 2007; Kern, & Shoemaker, 2002; Schein, Hazday, Pena, Ruben, & Sprung, 1990; Needleman & Buerhaus 2007; Hravnak, DeVita, Edwards, Clontz, Valenta, & Pinsky, 2008; Hravnak, Schmid, Ott, & Pinsky, 2011; Schmid, Hoffman, Happ, Wolf, & DeVita, 2007). It is therefore crucial that nursing surveillance provides timely recognition of deteriorating patient status before decompensation

becomes irreversible. There are many factors that impact the ability of providers to recognize instability and trigger the correct rescue interventions (Rubulotta & Pinsky, 2008; Chen, Bellomo, Flabouris, Hillman, & Finfer, 2009). The ability to recognize instability can be a challenge in the RD because patients are transferred from diverse units of origin and have a wide spectrum of acuity ranging from stable to critically ill. A recent search of the literature failed to identify any studies that evaluated nurse characteristics, e.g., nurse-to-patient ratio, staffing, skill, or patient characteristics, e.g., modifiable or non-modifiable risk factors, that predispose patients to FTR in the RD.

Vulnerable in-patients may be at risk for instability while undergoing diagnostic testing which, in some cases, may progress to cardiorespiratory collapse. When instability occurs, one method of early rescue intervention involves activation of a Medical Emergency Treatment team (MET) to bring an experienced cadre of critical care providers to the unstable patient. While utilization of a MET as part of an organization's Rapid Response System has been shown to reduce the number of patients experiencing adverse outcomes across the non-critical care units of hospitals, a more proactive approach would be to prevent acute instability or intervene prior to a MET activation (DeVita et al., 2004; Bellomo et al, 2004; Winters, Pham, & Pronovost, 2006; Winters, et al. 2007; Hillman et al., 2001; 2002; Smith & Wood, 1998; Goldhill, White, & Sumner, 1999; Rivers et al. 2001). Research has shown that changes in physiologic parameters can be detected hours before instability reaches rescue threshold, and that early intervention improves patient outcomes (Schein, et al., 1990; Needleman & Buerhaus 2007; Hravnak, et al., 2008; Peberdy et al., 2007). However, research has yet to provide an adequate means of identifying those patients at greatest risk for instability.

Although the literature describing MET activations and outcomes on clinical units within the hospital is fairly extensive, little is known about the characteristics of patients who require MET activation while in the RD (MET-RD), nursing surveillance, or patient outcomes. Once known, interventions could be tested to improve outcomes by identifying patients at highest risk and by modifying organizational characteristics. More information about precursors of FTR events could inform future interventions to improve patient outcomes and change patient care practices in the RD. Additionally, knowing if RD patients are more likely to be in need of the MET as compared to other hospital care areas would inform RD care practices and policies.

Therefore, the purpose of this exploratory pilot study is to describe characteristics of hospitalized patients who experience MET-RD activation, and their outcomes post MET-RD intervention. In addition, the study will compare the incidence of MET-RD to the incidence of MET activations occurring on general in-patient units of the same facility for the same time period.

1.1 SPECIFIC AIMS

The specific aims of this pilot study are to:

1. Describe the characteristics of hospitalized patients who experience MET-RD activation in regard to their:
 - a. Non-modifiable characteristics
 - b. Modifiable characteristics
 - c. Surveillance characteristics

2. Determine if there are differences in the characteristics of hospitalized patients who have a poor outcome post MET-RD (need for higher level of care post MET, FTR-do not survive to discharge), and those whose outcome is good (return to same level of care post MET, survive to discharge).
3. Compare the incidence of MET-RD to the incidence of MET activations occurring on general in-patient units of the same facility for the same time period.

1.1.1 Definition of Terms

- Non-modifiable patient characteristics = the patient characteristics at the time of their arrival in the RD that cannot be modified by policy change or practice improvements within the RD: age, gender, race, co-morbidity, admitting diagnosis, unit of origin, radiology procedure, requirement for respiratory support, drug infusions or sedation on arrival to the RD.
- Modifiable patient characteristics = management and clinical evolution in the RD; the level of patient support that can be modified by practice improvement within the RD: vital signs on arrival to the RD, changes in vital signs, drug infusion, sedation or respiratory support while in the RD; management of instability prior to intra-hospital transfer
- Instability = the movement of vital signs across the MET criteria threshold.
- Surveillance characteristics = numbers and skill level of personnel observing the patients; the aspects of care that can be modified by policy change or practice improvements within the RD: method of monitoring, level of surveillance (staff RN, radiology RN, patient care technician trained/untrained to read cardiac monitors, radiology technicians),

time elapsed between movement of vital signs across MET activation threshold and the MET-RD activation time.

- Need for Higher level of care = post MET-RD requirement for increased respiratory support (increased supplemental oxygen, hi-flow oxygen delivery system, ventilator settings, endotracheal intubation); increased vasoactive drug infusion, volume resuscitation), transfer for new procedure or surgery, transfer to a hospital unit with a higher level of monitoring than the unit of origin.
- FTR = Death of a RD-MET patient before discharge.
- Survival to discharge = patient survived to the date of hospital discharge.

1.2 CURRENT BACKGROUND AND REVIEW OF LITERATURE

Patient safety came to public awareness with the Institute of Medicine's (IOM) 2000 report that stated 98,000 people die annually due to medical error (Leape & Berwick, 2005). In the opinion of the IOM, as well as others, patient injuries due to error are caused by system failure, not poor practitioners (Leape & Berwick, 2005; Silber, Rosenbaum & Ross, 1995; Needleman & Buerhaus, 2002; Aiken, et al., 1999; Aiken, Clarke, & Sloane, 2002; Aiken, et al., 2002; Aiken, et al., 2008; Clarke & Aiken, 2003; Brennan et al., 1991). Silber et al. developed the concept "Failure to Rescue" which is defined as death that occurs after a patient develops a complication in the hospital. Silber et al. recognized that mortality rates do not provide a complete picture of

hospital quality of care and thus suggested FTR as a more accurate measure of hospital performance. FTR rates are impacted not only by the development of complications, but by a hospital's ability to vigorously intervene to rescue patients once a complication occurs (Silber, et al. 1992; Needleman & Buerhaus, 2002; Aiken, et al., 1999; Aiken, Clarke, & Sloane, 2002; Aiken, et al., 2002; Aiken, et al., 2008; Clarke & Aiken, 2003; Clarke, 2004).

1.2.1 FTR: Concept & Nursing Implications

FTR has become widely incorporated into measure sets to evaluate structures and process related to quality of hospital care, particularly the care of the most vulnerable patients. Organizational characteristics associated with FTR have been examined such as hospital size, number of board certified medical staff, number and educational level of registered nurses (RNs), ability to perform procedures such as magnetic resonance imaging or cardiac catheterization, and the presence of teaching programs, trauma services, and open heart and transplant surgical services (Silber, et al., 1992; 1995). In most FTR events, patient characteristics are found to be associated with risk for initial instability. However, hospital organizational characteristics have been shown to have an influence on patient survival, specifically the ratio of RNs to patient beds and the proportion of board certificated anesthesiologists (Silber, et al., 1995; Calzavacca et al., 2008; Bobay, Fiorelli & Anderson, 2008). Nursing staffing levels have also been identified as associated with FTR, as demonstrated in Aiken et al.'s seminal research regarding the relationship between the RN-to-patient ratios and educational backgrounds of nursing staff (proportion of BSN-educated RN staff) and FTR rates in surgical patients (Aiken, et al., 1999; Aiken, Clarke, & Sloane, 2002; Aiken, et al., 2002).

Needleman & Buerhaus examined nurse-staffing levels and their effect on hospital quality of care and reported that having higher proportions of patient care hours provided by RNs was associated with lower FTR in both medical ($p=0.05$) and surgical patients ($p=0.008$). Increased RN hours did not show an association with decreased hospital mortality rates, only with decreased rate of FTR. This study examined a large administrative dataset which provided a very large sample (> 5 million medical and >1 million surgical patients) and used a definition for FTR modified from that laid out by Silber. FTR was defined here as death from pneumonia, shock or cardiac arrest, upper gastrointestinal bleeding, sepsis or deep venous thrombosis (complications which were designated as “outcomes potentially sensitive to nursing”, i.e. likely to be affected by nursing care and indirectly by nurse staffing levels). These 5 complications were also hypothesized to be identifiable early and amenable to timely intervention which could influence the risk of death. In addition to FTR, Needleman & Buerhaus found number of RN hours per day associated with a decrease in length of stay, urinary tract infections, upper gastrointestinal bleeding, hospital-acquired pneumonia, shock and cardiac arrest. Taken together, these findings are consistent with models associating nursing factors with patient outcomes through nurses’ functions in surveillance, early detection and collaborative interventions to reverse patient instability (Needleman & Buerhaus 2007; Hravnak, et al., 2008; Hravnak, et al., 2011; Schmid, et al., 2007; Schmid-Mazzoccoli, Hoffman, Wolf, Happ & DeVita, 2008; Calzavacca et al., 2008; Bobay, et al., 2008).

Aiken et al. (2008) also identified the relationship between the hospital care environment, patient mortality, and FTR with nursing outcomes (nurse job satisfaction, burnout, intent to leave and nurse’s perceived quality of care). Utilizing a large sample of 10,184 nurses across 168 hospital and 232,342 surgical patients, Aiken demonstrated that significantly lower rates of both

death and FTR were associated with nurse-identified “better care environments”. Better care environments were defined as hospitals that scored above the median score on the Nursing Work Index subscales capturing organizational supports for high quality nursing care, nurse manager ability, leadership and support, and collegial nurse/physician relations. RNs working in hospitals described as “better care environments” reported increased job satisfaction and a more positive assessment of the patient care provided in their hospital than nurses working in “poor care environments”. This report confirmed prior research conducted by Aiken et al. (1999) that demonstrated the relationship between patient outcomes and the organizational structure directing patient care within hospitals. Additional studies on hospital staffing have shown statistically significant associations of RN staffing with risk-adjusted inpatient hospital deaths, further supporting the contention that RNs make key contributions to patient surveillance, complication detection and rapid intervention to prevent harm (Aiken, et al., 2002; Clarke & Aiken, 2003). However to date, none of these studies have focused on the physiologically vulnerable population of patients who require transport to the RD, which is a common and potentially risky element of many hospital patients’ stays.

1.2.2 FTR & Medical Emergency Treatment (MET) Teams

Some institutions have established MET teams to ensure that once instability is recognized, expert consultation in evaluating and managing critical instability is rapidly available. Team composition varies but most often includes a critical care physician, a critical care nurse and a respiratory therapist (Winters et al., 2007; DeVita et al., 2006; Sebat et al., 2007; Ranji, Auerbach, Hurd, O’Rourke & Shojania, 2007; Galhotra, DeVita, Simmons & Schmid, 2007). Bedside nursing staffs are provided with a preset list of criteria which signal the need to initiate a

MET call, and are educated and encouraged to use this resource. The purpose of the MET is to provide a secondary system of support at the bedside when patient deterioration is identified. As a process of care, the MET provides a means of making available ICU level care for unstable patients on all units throughout the hospital. The benefits of the MET derive from early recognition of patient deterioration, rapid response to changing inpatient status, and aggressive intervention to stabilize and rescue patients in order to prevent cardiopulmonary arrest (DeVita, et al., 2004; DeVita et al., 2006; Bellomo et al., 2004; Schmid, et al., 2007; Peberdy et al., 2007; Winters et al., 2007; Sebat et al., 2007; Ranji, et al., 2007; Galhotra, et al., 2007).

DeVita et al. (2004) developed a retrospective study conducted to compare mortality as a result of cardiac arrest before and after the initiation of the MET system in the data collection site, and reported a cardiac arrest risk reduction of 17% after MET system initiation, supporting the benefits of MET activation and aggressive intervention to prevent cardiac arrest. Bellomo et al. compared the incidence of serious adverse events, mortality after major surgery, and mean duration of hospital stay before and after initiating a MET activation system. They reported a relative risk reduction of 58% for serious adverse events, 37% for post-operative mortality and a decrease in length of stay after major surgery from 24 days to 20 days ($p=.0092$) after establishing a MET system. Several non-randomized, before-and-after cohort studies also reported that implementation of MET systems reduced the incidence of cardiac arrests, unexpected deaths, and unplanned ICU admissions (Peberdy et al., 2007; Hillman et al., 2005; Winters, et al., 2006; Subbe, Williams, Fligelstone & Gemmell, 2005; Buist, Harrison, Abaloz & Van Dyke, 2007; Jolley, Bendyk, Holaday, Lombardozzi, & Harmon, 2007; Chan, Renuks, Brahmajee, Berg, & Sasson, 2008). In contrast, the MERIT trial (Medical Early Response Intervention and Therapy) which assessed the impact of MET across 23 public hospitals in

Australia and 700,000 admissions, demonstrated no difference in mortality. However, the methodology for this trial has come under criticism, and a more recent post-hoc analysis of the MERIT data suggested that MET activation, when (importantly) called in advance of cardiac arrest, reduced unexpected cardiac deaths, overall cardiac arrests, and overall unexpected deaths, supporting the assertion early review and intervention of instability reduces mortality.

1.2.3 FTR & Surveillance

Empirical evidence supporting the need for early instability detection and intervention has been documented in the critically-ill and stroke patient populations (Prosser et al., 2007; Chein, et al., 2007; Kern & Shoemaker, 2002). Prosser et al. conducted a descriptive study of cardiac events following cerebral vascular accidents (CVA). Among their sample of 846 ischemic CVA patients, one out of five patients experienced at least one serious post-CVA cardiac event, and 4% died from cardiac causes. They theorized that due to the high mortality from cardiac events, vigilant cardiac assessment could increase survival. Chein et al. (2007) prospectively examined 89 patients with cardiac deterioration and 24 terminally ill patients at the time of death, and concluded that the earliest sign of circulatory compromise and death was evidenced by decreased blood flow and poor tissue perfusion. In this study, early treatment and hemodynamic optimization, enabled through early identification of decompensation, significantly decreased mortality (Schein, et al., 1990). Logically, findings from these studies can be generalized to the RD, as patients transported to the unit include those with the same diagnoses.

Several additional studies have reported findings that suggest that improved surveillance can detect complications earlier and prevent adverse outcomes (Hillman et al., 2001; 2002; Smith & Wood, 1998; Goldhill, et al., 1999; Rivers et al., 2001; Winters, et al., 2006). Schein et

al. (1990) studied clinical antecedents in 64 general hospital patients who experienced a cardiac arrest. In their study, 84% of the patients had documented clinical change within the 8 hours prior to their cardiac arrest, suggesting that cardiac arrest is a predictable event. Because survival from cardiac arrest is extremely low, efforts need to be made to intervene early in the deterioration process prior to the point of an arrest. Surveillance and early detection of patient instability are key components of the caregiver actions that Needleman and Buerhaus define as “rescue capacity”.

Instability onset is most commonly not acute, but demonstrates a cyclic pattern of change with patients moving above and below accepted parameters of heart rate (HR), blood pressure (BP), respiratory rate (RR) and oxygen saturation (SpO₂), usually hours prior to cardiorespiratory collapse. Due to the cyclic pattern of these dynamic variables, instability is often missed by intermittent clinical evaluation. Hravnak et al. evaluated the ability of a computerized integrated monitoring system that received continuous input of HR, BP, RR and SpO₂, to provide early detection of instability. They found that instability could be detected up to an average of 6.3 hours prior to traditional monitoring methods used by nurses and physicians. These findings suggest that patients have a cyclic pattern of instability over time that can be detected by nursing surveillance in the RD.

Schmid-Mazzoccoli et al. (2008) examined nurse, patient and organizational characteristics associated with MET calls on 5 medical and 5 surgical units at UPMC Presbyterian Hospital, (the same data collection site as this pilot study). Of the 108 events, 44% involved a delayed call, defined as MET calls with documented evidence that pre-established criteria for a MET call were present for >30 minutes prior to the call. More delays occurred on the night shift compared to the day shift (p=.012). Delayed events were not related to the number

of patients assigned ($p=.608$). However, there was a trend for more delays if more patients were assigned to the nurse (4 patients: 1 nurse = 21% vs. 6 patients: 1 nurse = 43%) at the time of the call. In a logistic regression model, shift and patient-unit-match, i.e., patients cared for on a medical unit by nursing staff “pulled” from a surgical unit or vice versa, were also a significant predictor of delays.

1.2.4 FTR & the RD

Approximately 12,000 hospitalized patients are seen in the RD of the study site at UPMC Presbyterian Hospital, each month. These patients represent multiple levels of acuity and therefore have varying physiologic support and surveillance needs. Patients who are critically ill often have traumatic injuries or unexplained complications which require the sensitive radiologic diagnostic procedures available in the RD. For example, a patient may develop respiratory distress with suspected pulmonary emboli or a patient may experience mental status changes of unknown etiology. In both examples these unstable patients require transport to the RD for diagnostic procedures in order to both establish the correct diagnosis and guide appropriate interventions. Patients in the RD may be accompanied by and cared for by ICU nursing staff assigned to their care, ICU nursing staff pulled to accompany them whom are less familiar with their care, or patient care technicians from their unit of origin. At the other end of the spectrum, patients are brought to the RD for general x-rays of minor bone fractures or diagnostic follow-up to document problem resolution. Once in the RD, all the patients are may be under the care of the RD RNs responsible for all RD patients at any given time. There is currently no decision rule either locally or in the literature to identify appropriate nursing surveillance for patients in the RD. The same MET activation system is utilized throughout the study site, including the RD, and

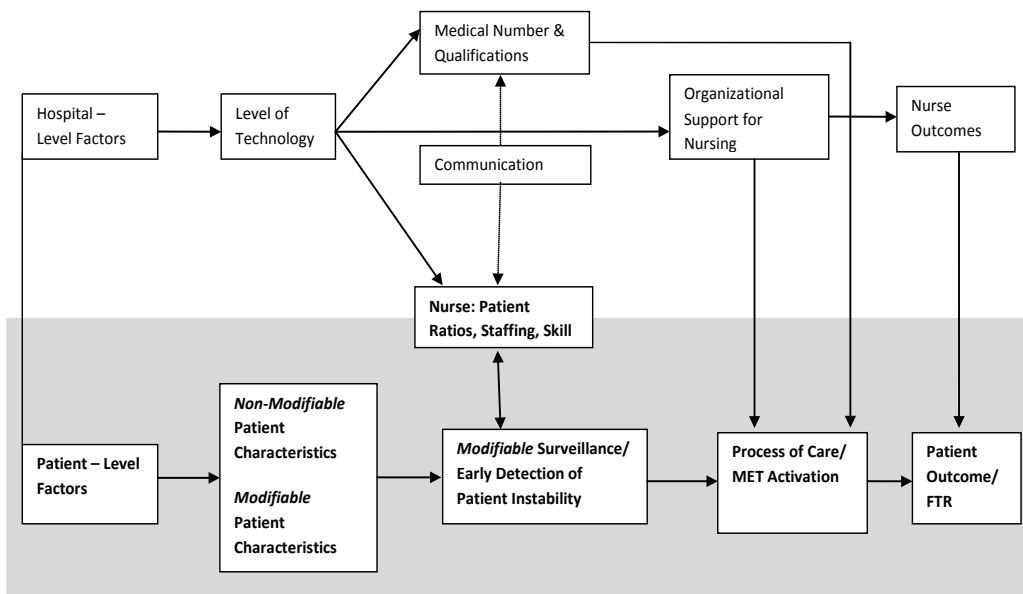
therefore the same activation criteria are used in all in-patient settings. An estimated 10 MET calls are initiated in the UPMC RD each month.

Since prior research suggests that heightened surveillance and early recognition of patient instability would improve patient outcomes (Prosser et al., 2007; Chein, et al., 2007; Kern & Shoemaker, 2002; Schein, et al., 1990), it is reasonable to hypothesize that heightened RD surveillance would similarly improve outcomes for those patients who experience instability in the RD. Studies conducted by Hravnak et al. indicate that evidence of instability may be present for as long as 6 hours prior to a MET call. Schmid-Mazzoccoli et al. reported that patients being cared for in areas where the direct care providers are mismatched for their care requirements, e.g., medical unit nurses pulled to a surgical unit or vice versa may be at greater risk for instability and the need for MET activation. It has yet to be determined if patients are at greater risk for instability and in need of the MET more frequently while in the RD compared to their assigned in-patient unit. Research identifying modifiable and non-modifiable characteristics of patients who experience an RD-MET call can target those individuals who are most likely to need and benefit from increased surveillance (Clarke, 2004; Winters, et al., 2006).

1.3 CONCEPTUAL FRAMEWORK

We have drawn from the FTR work of Silber and Aiken (Silber, et al., 1992; 1995; Aiken, et al., 2002) to develop an adapted FTR model (Figure 1) that depicts both hospital-level (including nursing) and patient-level characteristics that influence FTR (Hravnak, et al., 2011). This adapted model includes patient characteristics that are either non-modifiable (age, gender, co-morbidities,

etc.) or modifiable (variation in vital signs indicating movement between stability and instability). As depicted in the model, these patient characteristics as well as the level of surveillance influence the ability of nurses to recognize patient instability and call for MET activation in a timely manner. Ultimately patient outcomes are dependent on the interplay of these non-modifiable and modifiable characteristics, the early detection of instability and the ability to intervene early in the instability course. This study deals with the interrelationship of patient characteristics, level of surveillance, and outcomes of patients who require MET activation while in the RD (the shaded area of the conceptual framework (Figure 1)).



Hravnak, M., Schmid, A., Ott, L. & Pinsky, M. (2011) Causes of Failure-to-Rescue. In DeVita, Bellomo & Hillman (Eds) *Rapid Response Systems: Concept and Implementation*. New York, Springer

Figure 1. Hospital and Patient Level Factors Contributing to Failure to Rescue

1.4 SIGNIFICANCE OF RESEARCH STUDY FOR NURSING

The efficacy of the MET activation is dependent on both early identification of patient instability and early activation of the MET. Early identification can be enhanced by identifying patients at higher risk of becoming unstable and improving surveillance to detect instability earlier. Studies that identify patient characteristics or changes in patient status that can be modified by interventions are needed to better define barriers that inhibit recognition of patient instability, such as staff availability, education and experience (Hravnak, et al., 2008; The Joint Commission, 2008; Clarke, 2007; Clarke, 2009). The literature supports the interrelationship of organizational characteristics, nursing surveillance characteristics, and patient characteristics as contributory factors of FTR and the rescue interventions to improve patient outcomes. The patient characteristics that precede FTR are the least understood of these factors. Further study is needed to understand how patient characteristics influence FTR. The Joint Commission has developed National Safety Goals, #16 being to "improve recognition and response to changes in patients' condition" (The Joint Commission, 2008). Hospitals are required to implement early intervention programs and evaluate the effectiveness of such programs as a measure of quality. In order to do so, and improved understanding of patient and surveillance characteristics influencing patient instability is needed.

No studies were identified that examined patient instability, patient surveillance, MET activations or FTR in the RD. Identification of patients at greatest risk for instability while undergoing RD tests and procedures could influence RD policy of patient/nurse staffing, scheduling of RD admissions, and patient surveillance, and ultimately improve the safety of physiologically vulnerable patients while providing further understanding of the patient characteristics influencing FTR (Peberdy et al. 2007; Clarke, 2004). The results of this pilot

research could influence the design of staffing models, staff orientation and competency maintenance in the RD (Clarke, 2007; Clarke, 2009). Furthermore, this pilot study could provide the foundation for further inquiry into identification of the in-patient hospital population most vulnerable for instability and FTR.

1.5 PRELIMINARY STUDIES

The candidate conducted a preliminary pilot study consistent with the specific aims of the dissertation protocol to evaluate data availability and data acquisition techniques. The study was approved as a Quality Improvement Initiative by the UPMC patient Safety Committee and Total Quality Council (Appendix A). The purpose of the preliminary study was to describe the MET-RD activation etiology for hospitalized patients, temporal attributes of MET-RD, characteristics of MET-RD patients, and explore characteristics associated with good and poor outcomes post-MET-RD. The methods were a retrospective identification of MET-RD calls for in-patients (n=64) in a tertiary care hospital (01/01/2009-12/31/2009). The pilot study results showed MET-RD call etiologies were 39% neurologic, 38% cardiac, and 22% respiratory. Nearly half occurred during a Computerized Tomography scan (42%). Most MET-RD calls were made between 1000 AM – 1200 noon. MET-RD patients had a mean age of 61±19 years, were 52% female, and 89% white. Admitting diagnoses were most commonly neurologic (20%), cardiovascular (16%), and abdominal (16%). The most common co-morbidities were COPD (23%) and diabetes (20%). Half of MET-RD in-patients were from a general ward, and 56% were on supplemental oxygen beforehand. Following MET-RD, 61% of patients required a higher level of care, 3% died during the MET, and 19% died later in hospitalization. Patients with preexisting co-morbidities were

more likely to have poor outcomes post RD-MET ($p=0.001$). In conclusion, the MET-RD patients with co-morbidities, from a ward, and at risk for neurologic deterioration arrived in the RD with potentially underestimated support needs. Greater support in specific time frames and locations may be warranted to improve outcomes.

The results of the preliminary pilot study were accepted for publication in the American Journal of Critical Care (AJCC) with an anticipated publication date of November 2011. The complete citation is as follows: Ott, L., Hravnak, M., Clark, S., Amesur, N., (in press) Describing Patient Instability, Emergency Response and Outcomes in the Radiology Department: A Pilot Study. *AJCC*.

2.0 RESEARCH DESIGN AND METHODS

2.1 STUDY DESIGN

This pilot study utilized a descriptive comparative design to describe characteristics of patients who became unstable during radiologic tests and procedures, and determined characteristics that influenced poor outcomes. Since little is known regarding instability experienced by patients while they are away from the in-patient units for test and procedures, this phenomenon needs to be described to inform further inquiry or potential interventions identified. Selected non-modifiable patient characteristics, modifiable patient characteristics and surveillance characteristics were examined to identify factors that preceded MET activation in the RD, and characteristics associated with poor outcomes post MET rescue. Additionally, the event rate of MET for in-patients in the RD (MET-RD) relative to the hospital in-patient units (MET-W) was determined to assess if the RD population is more vulnerable or at-risk.

Data were obtained from four data sources: 1) the Medical Emergency Intervention and Treatment (MERIT) database which includes data specifically associated with a MET event, 2) the Medical Archival and Retrieval System (MARS)/Cerner data repository for clinical, administrative and billing data, 3) the Radiology Assessment Database (RAD) which includes electronic radiologic departmental and some clinical and procedural data, and 4) the paper record generated in the RD that contains more detailed information not included in the RAD i.e. medications administered and other details regarding RD patient care.

2.1.1 Research Setting

The setting was the University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital. UPMC Presbyterian is an approximately 900-bed adult tertiary care hospital located in Southwestern Pennsylvania, which admits approximately 32,000 patients per year. The hospital is a regional referral center for patients from the surrounding area and 20 facilities affiliated with the UPMC. In addition to general medical and surgical units, the hospital includes numerous specialties, including organ transplantation, cardiology, cardiothoracic surgery, critical care medicine, trauma services, and neurology and imaging services. UPMC is a pioneer in electronic medical records and has extensive electronic databases which can be accessed to provide the required data for analysis.

2.2 STUDY POPULATION & RECRUITMENT

The sample included all hospital in-patients over 18 years of age who experienced a MET activation while in the RD between May 1, 2008 and April 30, 2010. Initially there were 240 patients identified by the MERIT database as experiencing a MET-RD. Eleven patients were eliminated as not RD patients, 17 were eliminated as a non RD MET call and 102 patients were outpatients. There were 111 in-patients in the final sample. Data collection was limited to 2 years to minimize practice variations that occur over time in the hospital environment.

2.2.1 Subject Inclusion & Exclusion Criteria

Inclusion criteria: All adult in-patients over 18 years of age who experienced a MET activation while in the RD for a procedure from May 1, 2008 thru April 30, 2010. All in-patients who experience a MET activation in the RD were included despite potential missing data in order to accurately describe the occurrence and the diurnal pattern of MET activations.

Exclusion criteria: 1) Children under 18 years of age were excluded due to the unique patterns of instability and surveillance required and special training necessary for pediatric care; 2) patients experiencing a MET activation while in transit to and from the RD were excluded due to the special circumstances surrounding patient transports that are outside the scope of this analysis; 3) patients who experienced a MET in the RD who were not in-patients (i.e. ambulatory, outpatients).

2.3 STUDY VARIABLES

2.3.1 Non-modifiable patient characteristics

Defined as patient characteristics that are present at baseline or cannot be modified by policy change or practice improvements within the RD and will include:

1. Demographics = age, gender, race
2. Medical condition = admitting diagnosis, unit of origin (medical, surgical, step-down, ICU, other)

3. Radiology procedure = Magnetic Resonance Imaging (MRI), Computerized Tomography (CT), Ultrasound(US), Nuclear Medicine (NM), Peripheral Vascular (PV), Interventional Radiology (IR), General X-ray (X-ray), other
4. Co-morbidity = score on the Charlson Comorbidity Index
5. Respiratory support on RD arrival = none, mechanical ventilation, other
6. Cardiovascular support on RD arrival = none, maintenance, inotrope, volume expansion, other;
7. Cardiac arrhythmia on RD arrival = none, arrhythmia present
8. Sedation on RD arrival = none, intravenous (IV) lorazepam (Ativan) or propofol, other

2.3.2 Modifiable patient characteristics

1. Change in vital signs after arrival that meet or exceed MET activation threshold criteria, and duration of time across the threshold.
2. Change in respiratory support during procedure to maintain instability (supplemental oxygen, ventilator changes)
3. Change in cardiovascular support during procedure to maintain blood pressure, e.g. volume expansion, initiation or change in support medications.
4. Change in cardiac rate and rhythm without intervention (yes, no)
5. Sedation during procedure: IV lorazepam (Ativan), propofol, conscious sedation, general anesthesia
6. Vital Signs recorded during the 12 hours prior to arrival to the RD. Vital signs to include temperature, pulse, respiratory rate, blood pressure (systolic, diastolic and mean arterial pressure)

if indicated) and pulse oximetry with supplemental oxygen support at the time of the vital sign measurement.

2.3.3 MET activation criteria for UPMC Presbyterian Hospital

The MET was introduced as a component of care at the study site in 1998. Responders include an intensive care physician, intensive care nurse, nurse anesthetist and respiratory therapist. The team can be summoned by anyone in the hospital (RN, nursing assistant, transport aide, information desk clerk) at any time by calling extension 7-3131. The call creates an electronic page and overhead speaker announcement placed by the hospital operator. The operator records the location and type of condition.

The institution specific criteria designating when to summon the MET team are as follows:

1. Respiratory Rate : $<8/\text{min}$ or $>36/\text{min}$, new onset difficulty breathing, new $\text{SpO}_2 <85\%$ for >5 min (unless known chronic hypoxemia), new requirement for supplemental oxygen $>50\%$ O_2 to maintain $\text{SpO}_2 85\%$. Heart Rate: <40 or $>140 \text{ min}^{-1}$ with new symptoms; any rate $>160 \text{ min}^{-1}$
2. Blood Pressure: systolic <80 or $>200 \text{ mm Hg}$, diastolic 110 mmHg with symptoms (neurologic changes, chest pain, and dyspnea)
3. Neurologic Change: Loss of consciousness, new onset lethargy, sudden loss of mobility of face, arm or leg, sudden collapse, seizure (outside seizure monitoring unit)
4. Other Criteria: >1 STAT page required to assemble team needed to respond to a crisis, patient complaint of (cardiac) chest pain (unresponsive to nitroglycerine, or MD unavailable, color change (of patient or extremity): pale, dusky, gray or blue, unexplained agitation of > 10 min,

suicide attempt, bleeding into airway, Narcan use without immediate response, uncontrolled bleeding, large acute blood loss, crash cart must be used for rapid delivery of medications

2.3.4 Modifiable surveillance characteristic

Defined as aspects of care that can be modified by policy change or practice improvements within the RD:

1. Method of monitoring = any combination of cardiac monitor, SpO₂, BP or no monitoring;
2. Level of surveillance = patient is monitored during the procedure by a staff RN, radiology RN, patient care technician trained to read cardiac monitors (APCT), or the radiology technician performing the procedure only;
3. Diurnal variation = time of day of MET activation
4. Duration of time between movement of vital signs across MET activation threshold and MET-RD call

2.3.5 Patient Outcomes/FTR

1. Survival to discharge = alive at hospital discharge post MET-RD call.
2. Higher level of care required =
 - a) increased respiratory support; increased supplemental oxygen, hi-flow oxygen delivery system, increased ventilator settings, endotracheal intubation
 - b) increased cardiovascular support: vasoactive drug infusion, volume resuscitation
 - c) transfer for procedure or surgery
 - d) transfer to a hospital unit with a higher level of monitoring than the unit of origin

2.3.6 Incidence of MET-RD and Incidence of in-patient MET

The incidences of MET-RD activations were measured as the number of MET activations in the RD for patients whose unit of origin is an in-patient unit per 1000 in-patient admissions to the RD (procedures performed in the RD). The incidences of MET activations in hospitalized in-patients were measured as the number of MET activations for in-patients per 1000 in-patient hospital admissions.

2.3.7 Study Variables and Databases

Table 1. Study Variables and Databases

Study Variables	MERIT Database	MARS/ Cerner Database	RAD	paper chart
<i>Non-modifiable patient characteristics</i>				
1. Demographics:				
Age	X	X	X	X
Gender	X	X	X	
Race	X	X		
2. Medical condition:				
Admitting diagnosis	X	X		
Unit of origin	X	X	X	X
3. Radiology modality	X	X	X	X
4. Co-morbidity index		X		
5. Respiratory support: none, mechanical ventilation, other	X	X	X	
6. Cardiovascular support: none, maintenance, inotrope, volume expansion, other	X	X		
7. Cardiac rhythm: none, arrhythmia present on arrival		X		
8. Sedation: none, intravenous (IV) lorazepam or propofol, other.		X		
<i>Modifiable patient characteristics</i>				
1. Change in any MET criteria after arrival that meets or exceeds MET activation threshold criteria without intervention.	X		X	X
2. Change in respiratory support during procedure to maintain instability (supplemental O ₂)	X		X	X
3. Change in cardiovascular support during procedure to maintain BP.	X		X	X
4. Change in cardiac rate and rhythm without intervention (yes, no)	X		X	X
5. Sedation during procedure: IV lorazepam, propofol, conscious sedation, general anesthesia	X		X	X
6. Vital Signs during the 12 hours prior to arrival to the RD. Temperature, pulse rate, blood pressure, pulse oximetry and supplemental O ₂ requirements		X		
<i>Modifiable surveillance characteristic</i>				
1. Method of monitoring = any combination of cardiac monitor, SpO ₂ , BP or no monitoring;			X	X
2. Level of surveillance = patient monitored during the procedure by a staff RN, radiology RN, patient care technician trained to read cardiac monitors (APCT), or the radiology technician performing the procedure only;		X	X	X
3. Diurnal variation = time of day of MET activation	X			
4. Time between movement of vital signs across MET activation threshold and the RD-MET call time	X		X	X
<i>Patient Outcome</i>				
1. Survival to discharge = alive at hospital discharge post RD-MET. Date of death or date of discharge.		X		
2. Higher level of care required	X	X		

2.4 DATA COLLECTION AND MANAGEMENT

2.4.1 Data Collection and Management: Specific Aims 1 & 2

Data Collection and Variables of Interest: We recorded the number of MET-RD calls and the time of day and day of week at which they occurred. Time of day was categorized by 4 hour increments for analysis. The characteristics of patients before RD transport (demographics, admitting diagnosis by ICD-9 code, Charlson Comorbidity Index individual and total scores, ICU or non-ICU unit of origin, care needs and vital signs in the 12 hours before RD arrival) and during RD care (RD modality, RD care needs, type of RD caregivers) were extracted from the electronic medical record or the administrative database. Admitting ICD-9 codes were categorized into 8 related categories representing primary diagnosis.

Care needs in the 12 hours prior to RD transport were also identified. Respiratory support was identified with respect to the need for any supplemental oxygen delivery system and type of respiratory support (nasal cannula, face mask, mechanical ventilation). Cardiovascular support included documentation of inotropic medications and/or fluid resuscitation and need for blood products. Cardiac arrhythmias were determined by nursing documentation of cardiac assessment. Sedation prior to the RD was recorded and included propofol, diazepam, morphine, fentanyl, alprazolam, hydromorphone, midazolam, succinylcholine and/or vecuronium. Vital signs were categorized according to MET call criteria (Section 2.3.3). In addition, tachycardia was defined as a heart rate > 100 beats per minute and a respiratory rate >24 breaths per minute and tachypnea as >30 breaths per min. The RD modality at the time of the MET-RD and the etiology of the MET-RD call were obtained from the MET call record, and defined as a cardiac, respiratory, neurologic or other primary reason for the call. Sedation in the RD consisted of

administration of lorazepam, hydromorphone, midazolam, fentanyl, propofol, succinylcholine or Vecurium. Monitoring in the RD consisted on any combination of cardiac, blood pressure or pulse oximetry. The level of RD surveillance was described according to four caregiver categories: (a) RD technician (responsible for conducting the test ordered for the patient), (b) staff RN (general ward, resource pool or ICU staff) who accompanied patient to the RD (c), RD RN (RD-unit assigned), or (d) advanced patient care technicians (trained unlicensed care providers who accompany monitored patients during intrahospital transport).

Patient outcomes were classified as either returned to their prior usual care post MET-RD, or as requiring a higher level of care. A composite outcome of need for a higher level of care was defined as increased respiratory support (nasal cannula, high flow oxygen, mechanical ventilation), increased cardiac support (fluid resuscitation, blood products, pharmacologic blood pressure support or cardiac rhythm support), need for emergent procedure (angiography, cardiac cath lab, central venous catheterization, electroencephalogram, electrocardiogram, CT, MRI, operating room), or transfer to a higher acuity patient care unit, and/or death between the time of the MET-RD and discharge. Death was also utilized as a single outcome. To assess interrater reliability, 10% of records were reviewed by both data collectors and results compared for variations in data collections, with no deviations noted between data collectors.

2.4.2 Data Collection and Management: Specific Aim 3

To determine the event rates for the target year (2009), the following data were obtained from hospital databases: 1) number of admissions; 2) number of MET calls to the RD and general wards; 3) hospital length of stay (LOS); and 3) number of RD admissions by RD modality, i.e.

magnetic resonance imaging (MRI), computed tomography (CT), interventional radiology (IR), nuclear medicine (NM), general x-ray including fluoroscopy (XR), and ultrasound (US). There were 1553 MET-W calls and 30,811 hospital admissions with an average LOS-hospital of 6.7 days. There were 56 MET-RD calls and 149,569 RD admissions with an average LOS-RD of 58 minutes.

Event rate: To determine an event rate for MET-RD and MET-W, the incidence of MET-RD and MET-W were first determined and then adjusted for the time spent in hours (length of stay) in the respective areas. Figure 2 summarizes the equations used to calculate MET-RD and MET-W event rates. The incidence of MET-RD and MET-W (Figure 2A) was calculated for each month and the year (Table 4). Event rates of MET-RD and MET-W (Figure 2B) were calculated as the number of MET-RD calls/hour/1000 Radiology admissions and the number of MET-W calls/hour/1000 hospital admissions.

Length of Stay: Hospital LOS was retrieved from the administrative database as an average for each month and the year. There was no recorded LOS-RD therefore LOS-RD was calculated using hospital transport data, defined as the time in minutes away from the hospital unit for an RD procedure. The transport data provided the time of transport from the hospital unit to the RD (“to RD”) and the time of transport from the RD to the hospital unit (“from RD”). As a preliminary step, LOS-RD calculations were determined for one month (January 2009). There were 2,354 entries after eliminating all outpatient visits. Data for these 2,354 patients were then merged by patient name, date and RD modality, i.e., MRI, CT, IR, NM, XR and US to determine modality specific LOS-RD. After merging, 471 patients (20%) had missing data.

To address the large amount of missing data, an imputation was conducted. First we compared the time “to RD” of patients with complete data (M=7.42 minutes, SD=4.25) with

those patients missing time “from RD” data (M=7.18 minutes, SD=4.54). The time “to RD” data was not significantly different, $p=0.39$. Similarly, the time “from RD” of patients with complete data (M=6.69 minutes, SD=4.09) was compared to the time “from RD” of those patients missing time “to RD” data (M=7.10 minutes, SD=10.62). The time “from RD” was not significantly different, $p=0.27$. Thus, we used the average time “to RD” (M=7.39 minutes) and “from RD” (M=6.74 minutes) for the entire data set when patients had missing data.

To determine the time spent in the RD itself, the scan start time was retrieved from the medical record for all patients with missing data and the scan duration time was retrieved for all patients missing data for time “from RD”. These data were used to impute missing data and determine LOS-RD; the resulting formulae are found in Figure 2C.

After imputation, the missing transport data was reduced to 3.82%. The average \pm SD LOS-RD in minutes for patients with complete data was 58.05 ± 37.61 minutes, for patients with imputed data 56.51 ± 40.83 , and the average LOS-RD of all patients was 57.8 ± 38.16 minutes. The same analysis was conducted for two additional months. For all three months, missing transport data was reduced to $\leq 5\%$ using the previously described method of imputation. Additionally, the average LOS-RD for patients with complete data and for all patients after imputation was virtually the same (< 30 seconds difference in LOS-RD). Our method for imputing the LOS-RD using clinical data demonstrated that there was no difference in the LOS-RD for patients with complete and missing transport data. Therefore, LOS-RD calculations were only determined for patients with complete transport data.

<p>A. Equations to calculate the incidence of medical emergency team calls in the RD and Hospital</p>
$\frac{\# \text{ MET-RD in 2009}}{\text{RD in-patient admissions in 2009}} \times 1000 = \text{incidence/1000 RD admissions}$
$\frac{\# \text{ MET in 2009}}{\text{Hospital admissions in 2009}} \times 1000 = \text{incidence/1000 Hospital admissions}$
<p>B. Equations to calculate the event rates for medical emergency team calls in the RD and Hospital</p>
$\frac{\text{incidence /1000 RD admissions}}{\text{average LOS in RD/60 minutes}} = X \text{ events/hour/1000 RD admissions}$
$\frac{\text{incidence/1000 hospital admissions}}{(\text{average hospital LOS in days} \times 24 \text{ hour})} = X \text{ event/hour/1000 hospital admissions}$
<p>C. Equations used to calculate the LOS-RD for patients with missing transport data.</p>
<p>Time returned to unit – time departed from unit = LOS-RD for patients with complete data</p> <p>Time returned to unit – (7.39 min +scan start time) = LOS-RD for patients missing “to RD” data</p> <p>(Scan time + scan duration + 6.74 min) – time departed from unit = LOS-RD for patients missing “from RD” data</p>

Figure 2. Equations to calculate incidence and event rates of medical emergency Team calls in Radiology (MET-RD) and the Hospital (MET-W)

2.4.3 Data Management

Data collection was conducted with the use of a research team consisting of the PI and research assistants from Biomedical Informatics, MERIT committee and a graduate student data collector. The PI, as a UPMC employee with access to the data elements as a function of her employment in the Radiology department, was covered under the IRB HIPPA and consent waivers. The

research team worked under the guidance of the PI. All data was de-identified once all databases have been accessed and variable data collected. All variables were then be coded and input into the SAS study database. Once data was been cleaned, variables and values were labeled and missing values identified to create the data files for analysis. All data were kept in a secure password protected electronic database and a locked file in the University of Pittsburgh School of Nursing. The PI has sole access to the data files.

3.0 STATISTICAL MANAGEMENT PLAN

3.1 DESCRIPTIVE STATISTICS

Descriptive statistics were used to describe the data numerically and graphically. The categorical variables were described using frequency distributions. Bar graphs were used to graphically evaluate each categorical variable for shape of distribution and central tendency (mode). Both the frequency and proportion were reported for all categorical variables.

The continuous variables are ratio scale and were described for central tendency (mean for normal distributions and median for non-normal distributions), spread (standard deviation for normal distributions and inter quartile range for non-normal distributions) and the range of minimum and maximum values. The continuous variables were described graphically using histograms, stem and leaf and Q-Q plots.

3.2 DATA SCREENING PROCEDURES

First, exploratory analyses were conducted to identify data anomalies, looking for inconsistency in the data and potential data entry errors. Frequency distributions for discrete variables and means, standard deviations and range for continuous variables were examined for coding errors, invalid or improbable responses and missing values. The inconsistencies found in the data were

resolved by checking the data against the data collection forms and patient records. Independence of observations was satisfied as each record represents a separate MET-RD event.

Outliers were handled on a case by case basis examining each for possible data entry error. If the outliers are deemed valid responses, then the other analysis were run with and without the outliers to determine the outliers influence. Missing values in the categorical variables were rare and random. Large amounts of missing values were found in the documentation of change in MET criteria in the RD, change in the respiratory support, change in cardiovascular support and change in cardiac rate and rhythm in the RD making it necessary to eliminate these variables from further analysis. There were no subjects with a large amount of missing data in any other variables.

The continuous variables were also screened for outliers and linearity using scatterplots, Q-Q plots and box and whisker plots. Outliers were handled as described above. Continuous variables were be screened for linearity in the logit by transformation into temporary categorical variables using quartiles and graphically displayed as bar graphs. In the event of sparse cells the data were transformed by collapsing the data into clinically relevant categories where possible. The collapsed categories were done with the goal of greater than 10% of the sample in each cell. Once the data screening procedures was completed, analysis of the data to satisfy each specific aim was conducted.

3.3 SPECIFIC AIM 1

Describe the characteristics of in-patients who experience a MET activation while in the RD in regard to their: a. Non-modifiable patient characteristics, b. Modifiable patient characteristics, c. Modifiable surveillance characteristics.

The detailed descriptive analyses of the data, using standard descriptive summaries (e.g., means, standard deviations, medians, inter quartile range, percentiles, ranges and frequencies) and graphical techniques (e.g., bar graphs, histograms, scatter plots) were used to describe the non-modifiable patient characteristics, modifiable patient characteristics and modifiable surveillance characteristics. The frequency command in SAS was run for each nominal characteristic and each category was described as the frequency of occurrence and percentage of the total. Admitting diagnosis was analyzed as the frequency of occurrence of all ICD-9 codes. In addition the primary admitting diagnosis was categorized into categories and then analyzed for frequency and percentage of the total. Once the frequencies and proportions were obtained for all the categorical variables, the data were recoded to collapse the categories to obtain cells with greater than 10% of the total for strength in future analysis. However the original distributions were described to satisfy Specific Aim 1.

The normally distributed continuous variables were described as the mean and standard deviation of the original data and any transformed variable. The non-normally distributed continuous variables were described as median and inter quartile range. Age at time of MET-RD was computed in SAS as date of MET-RD minus the subject's birthday.

3.4 SPECIFIC AIM 2

Determine if there are differences in the characteristic profiles of patients who have a poor outcome post MET activation in the RD (Failure-to-Rescue [do not survive to discharge], require a higher level of care post MET) and those whose outcome is good (survive to discharge, return to same level of care post-MET).

The Student t-test was used to compare the means of the normally distributed continuous variables for analysis between two groups (patients with good outcomes and patients with poor outcomes). Cross tabulation in SAS was conducted to generate a contingency table for each categorical variable individually with higher level of care (yes, no) and again with death (yes, no) as the column variable and independent categorical variable as the row variables. The associations of significance were examined using Pearson Chi-square. Fisher exact test was used to examine the association of significance between the independent variables and outcomes when cells were sparse. Odds ratios with corresponding 95% confidence intervals were estimated to measure the strength of association between the dichotomous independent variables and poor outcome using the generated contingency tables.

A direct binary logistic regression with higher level of care post RD-MET (yes/no) as the dependent variable and with death (yes/no) was performed. Sufficient percentages in the dichotomous outcome measure cells satisfied the variability assumption for logistic regression. The categorical variables were indicator coded establishing a dummy variable for analysis. However no prediction model was possible there were no significant findings when entering variables into a model.

3.5 SPECIFIC AIM 3

Compare the incidence of MET activations for in-patients in the RD to the incidence of MET activations occurring on the general in-patient units of the same facility for the same time period.

The ratio of MET occurrence in the RD was measured by the number of MET activations in the RD during the study period per 1000 RD in-patient admissions (procedures) during the study period. The ratio of occurrence in the general hospital population was measured as the number of MET activations per 1000 hospital admissions. The incidence of MET activations was determined by the ratio of occurrence of new cases of MET activations over the total patient population at risk during one calendar year for in-patients in the RD and general in-patient unit respectively. The null hypothesis was that the incidence of MET activation was independent of location.

An event rate for MET-RD and MET-W was calculated from the incidence of MET-RD and MET-W, adjusted for the time spent in hours (length of stay) in the respective areas. The incidence of MET-RD and MET-W was calculated for each month and the year. Event rates of MET-RD and MET-W were calculated as the number of MET-RD calls/hour/1000 Radiology admissions and the number of MET-W calls/hour/1000 hospital admissions.

A 2x2 chi-square test was used to compare the difference of event rates between MET-RD and MET-W. The column variables were MET activations no (0)/yes (1) and the row variables were RD admissions (n=1000) and general in-patient admissions (n=1000).

3.6 SAMPLE SIZE

The sample for this study was enrolled by identification of all patients who had experienced a MET activation while in the RD in the two year time frame. The patients were screened and out-patients were excluded from the sample. The sample size was limited to events that occurred in the study interval. Due to the ongoing practice improvements of the clinical environment, the decision was made to limit the study to two years.

Sample size justification to have enough power to develop a predictive model for those patients at risk for poor outcomes post MET-RD was conducted utilizing the data from the previously conducted pilot study. This was done by obtaining odds ratios with 95% confidence intervals and the R² for all pilot predictor variables utilizing univariate logistic regression. PASS software was utilized to calculate the sample size needed for this analysis.

The poor outcome of requiring a higher level of care occurred in 67% of our pilot sample. Therefore the baseline proportion $p=0.67$ was used in the logistic regression model of the PASS software. The pilot predictor variables correlations ranged from .37 to .71. To evaluate the odds ratios for the predictor variables at different potential sample sizes, each correlation was placed in the model with a power = .80 and alpha = .50. The odds ratios for the largest expected sample of $n=130$ ranged from OR = 2.61, R²= .70 to OR = 11.28, R²= .47.

The sample size justification shows that the proposed study is conducted as a feasibility study due to the sample size limitations. Larger sample sizes than are possible in this study would be needed to overcome the high multicollinearity of the predictor variables in order to see statistically significant associations to predict poor outcomes post MET-RD.

4.0 HUMAN SUBJECT RESEARCH

4.1 RESPONSIBLE CONDUCT OF RESEARCH

The PI completed The University of Pittsburgh Education & Certification Program in Research & Practice Fundamentals, an on-line educational series designed to provide training to individuals employed by the University of Pittsburgh, and its affiliated institutions. The program consisted of required and optional modules, depending on one's research focus. There are four required modules:

Module 1- Research Integrity

Module 2- Human Subjects Research

Module 6- HIPPA Researchers Privacy Requirements

Module 14- UPMC HIPPA Staff Security Awareness Training.

Upon completion of this program, a certification was stored in a database and the examinee printed a hard copy of this certificate for their records and submission to the Public Health Service granting agencies. The PI successfully completed Modules 1, 2, 6 and 14. Certificates of successful completion are on file.

Ethical issues related to human subjects' research were completed as part of the doctoral courses including Nursing Theory and Research, Research Methods, Qualitative Research, Pilot Study, Grant Writing Practicum, Research Development and others. Areas covered in these

courses included ethical issues related to obtaining informed consent, participant confidentiality, conflict of interest, research integrity, protection of vulnerable subjects, internal audit procedures, seeking IRB approval, and adverse event monitoring. Further instructions were received through the various research seminars the PI attended including the Survival Skills Workshop, Research Methodology Series, and Research Progress Update Series available through the School of Nursing and University.

4.2 PROTECTION OF HUMAN SUBJECTS

All data was retrieved from a retrospective chart review of existing databases and then de-identified. The data were not be linked to specific patient identifiers once all data was collected from the four data sources (MARS, MERIT, RAD and Paper charts). The University of Pittsburgh Institutional Review Board reviewed and approved the study by the expedited review procedure authorized under 45 CFR 46.110 and 21 CFR 56.110 (Appendix B). All study data were stored in a locked filing cabinet in a locked office in the School of Nursing. All study data were managed in a secure password protected database. Research records will be maintained at a minimum of 5 years or as long (indefinite) as it may take to complete the research study. Individual responses will not be shared unless presented in aggregate and individual participants will not be identified by name.

4.3 WOMEN, MINORITY AND CHILDREN INCLUSION IN RESEARCH

4.3.1 Inclusion of Women and Minorities

This study enrolled both men and women who experienced a MET-RD during the study time frame. The current UPMC patient demographic composition by gender, race and ethnicity is 49% Female and 51% Male; 1% Hispanic, 99% Non-Hispanic with a Non-Hispanic population composition of 0% American Indian/Alaskan Native and Native Hawaiian/Pacific Islander, 5% Asian, 20% African American and 75% Caucasian. No one was excluded from participation in this study based on race, ethnicity or gender.

4.3.2 Inclusion of Children

The study setting was an adult tertiary care hospital where the care of children is a rare occurrence, however children under 18 years of age who experienced a MET activation in the RD were excluded from this study due to the unique patterns of instability and surveillance required and special training necessary for pediatric care.

4.4 DATA SAFETY AND MONITORING PLAN

Data and safety monitoring was conducted during monthly meetings with the dissertation chair. A summary of these reviews was provided to the IRB at the time of the yearly renewal. There was no change in exempt status.

5.0 RESEARCH RESULTS AND DISCUSSION: SPECIFIC AIMS 1&2

5.1 RESULTS FOR SPECIFIC AIMS 1 & 2

The distribution of the 111 MET-RD calls across day of week and time of day are illustrated in Figure 3. MET-RDs occurred more frequently in the middle of the week (Wednesday) and in the 0800-1200 time slot (30%), with descending frequency across the other time intervals (Figure 3).

Over 70% of patients required a higher level of care post MET-RD (Figure 4). Half required increased respiratory support and, of those not on mechanical ventilation prior to transport, 26% required mechanical ventilation. Of the 67 patients not admitted to an ICU prior to the MET-RD, 38 were transferred to a higher acuity unit, 28 were newly admitted to an ICU, and 10 were sent to monitored non-ICU beds. Of the 26 patients who required an emergent procedure post MET-RD, 7 were sent to the operating room. One in four MET-RD patients (25%) died during their MET event or during the remainder of their hospitalization.

Characteristics of the patients prior to their RD-transport resembled the overall characteristics of the hospital population, (Table 2. Panel A.), i.e. middle aged, Caucasian (81%) and with an equal distribution of females and males. Patients were evenly distributed across admitting diagnosis categories with a slightly higher proportion with a neurologic diagnosis (24%). The average Charlson Comorbidity Index was approximately 4, with the most common comorbidities being renal (61%), cerebral vascular disease (28%), diabetes (22%), myocardial

infarct (21%) and cardiopulmonary disease (20%). The majority of the patients (60%) originated in non-ICU units. Almost half (43%) experienced the MET-RD on their first day of hospitalization. Most (65%) were on respiratory support, most commonly by nasal cannula oxygen (38%). In addition, 25% required cardiovascular support and 23% received sedation prior to transport. Cardiac arrhythmias were documented in 27%. In the 12-hours prior to RD-MET, 16% of the patients had at some point met or exceeded MET call vital sign thresholds. Although only 5% and 2% exceeded MET criteria for respirations and heart rate respectively, however, 42% experienced tachypnea and 34% experienced tachycardia below MET call thresholds.

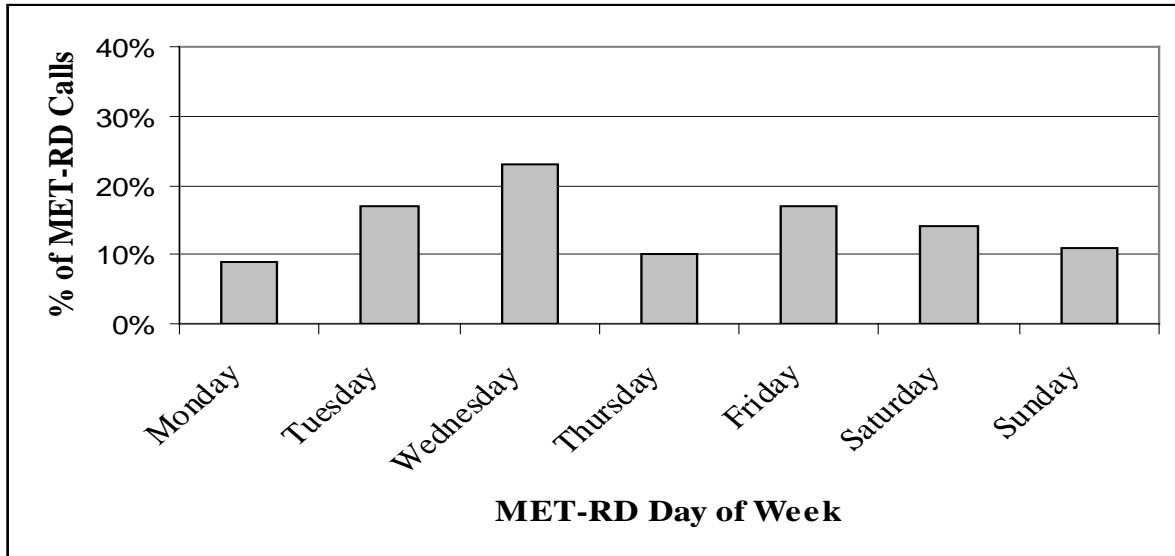
When evaluating the association between patient characteristics prior to RD transport and the outcome of need for a higher level of care post-MET (Table 2. Panel B), patient demographics were evenly distributed with no significant associations between patients requiring higher care and those that were returned to their prior unit. However, several trends were noted. Not surprisingly, non-ICU patients more often required a higher level of care as did patients who arrived on nasal cannula oxygen (28%, $p=0.15$). More patients with respirations >30 breaths per min (92%) required a higher level of care compared to 77% with respirations ≥ 24 breaths per minute.

When evaluating the association between patient characteristics prior to RD transport and the outcome of mortality in the post-MET hospitalization phase (Table 2 panel C), we saw a non-statistically significant trend toward increased mortality for males (68%) as compared to females (32%), $p=0.09$. For patients who died, a significantly greater proportion originated from an ICU (57%) than a ward (43%, $p=0.03$) and 39% were receiving cardiovascular support prior to the RD. Of those who survived, 17% were on prior cardiovascular support ($p=0.02$). However a prior cardiac arrhythmia was not associated with higher mortality.

The majority of MET-RDs occurred in CT (44%) and MRI (22%) (Table 3, Panel A). MET-RD etiology was most commonly cardiac (41%) with the MET triggers of hypotension, cardiac arrhythmias and chest pain (n=19, 18, 8, respectively). Respiratory MET-RD etiology (29%) triggers were hypoxia (23%) and airway protection (7%). Neurologic MET-RD etiology (25%) triggers were seizures (14%), altered mental status (9%) and stroke (1%). Other MET-RD triggers were falls, dislodged central venous catheters (2%) and the need for additional ICU personnel (2%).

There also appeared to be differences in surveillance. A majority of the MET-RD patients (57%) were on continuous vital sign monitors while in the RD, but less than half were under the surveillance of a staff nurse (general ward, resource pool, ICU). When examining the outcome of mortality (Table 3. Panel C), the patients who were monitored in the RD and those with staff nurse surveillance in the RD were more likely to die during hospitalization.

A.



B.

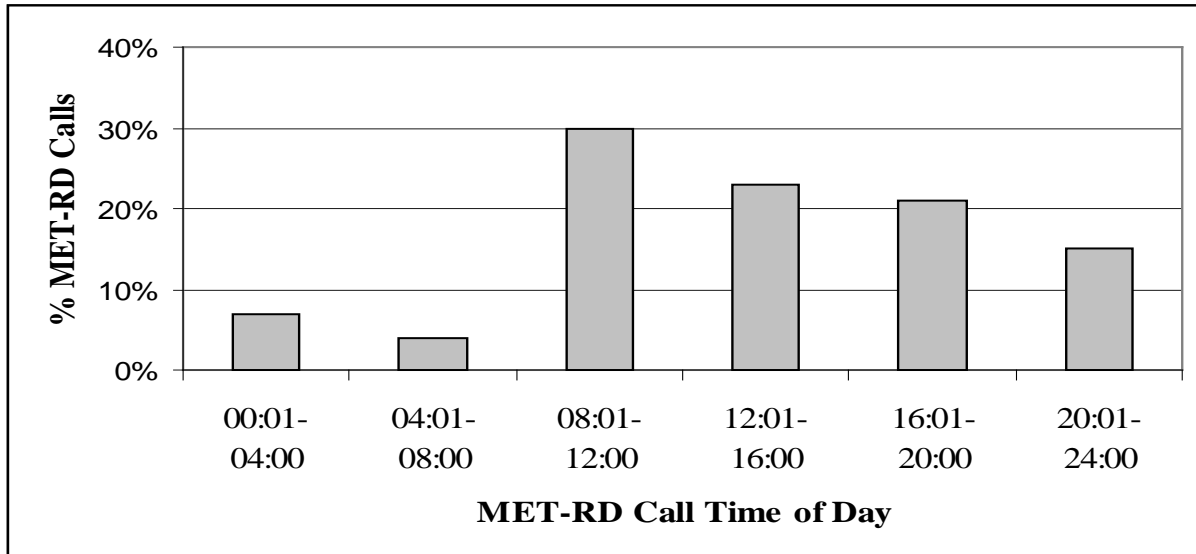


Figure 3. Distribution of 111 MET-RD (Medical Emergency Team to Radiology Department) Calls according to day of the week (Panel A) and time of day (Panel B).

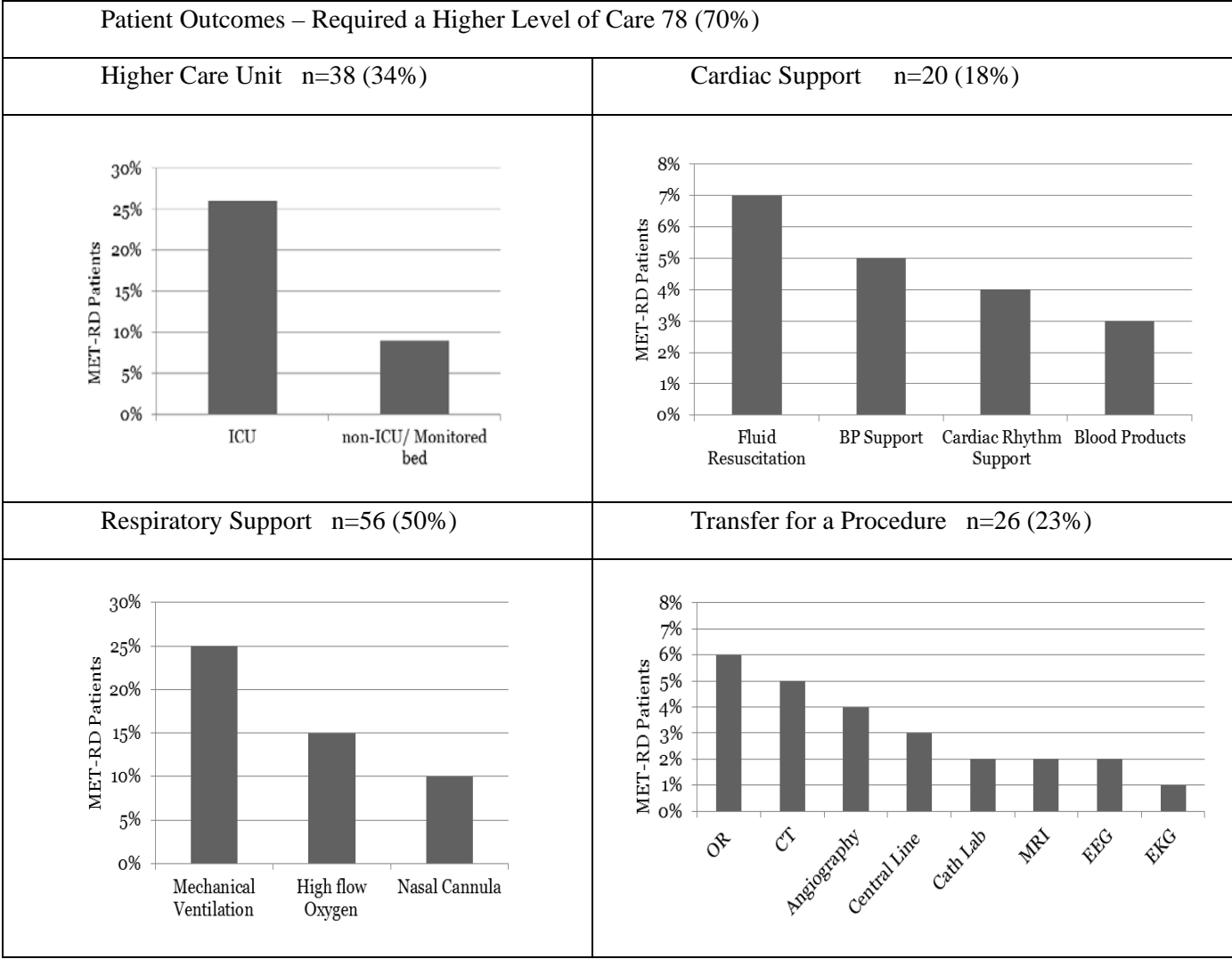


Figure 4. Patient outcomes for 111 patients post Medical Emergency Team call in the Radiology Department categorized by those patients requiring a higher care unit, cardiac support, respiratory support and/or an immediate procedure.

Table 2. The total sample demographic and care requirement characteristics of 111 patients who required a Medical Emergency Team call to the radiology department (MET-RD) prior to their transport (Pre-RD) (Panel A), and comparisons of characteristics according

Characteristics		Post MET-RD Patient Outcomes					
A. Pre-RD Patient Demographics and Care Requirements	n (%) Mean (±SD) n=111	B. Care Requirements			C. Mortality		
		Usual Care n=33	Higher Care n=78	p	Survive to Discharge n=83	Death n=28	p
Age Median (range)	60 (18) 62 (18-93)	57 (20)	61 (18)	0.22	57 (19)	67(14)	0.02
Female	51 (46%)	19 (57%)	32 (41%)	0.11	42 (51%)	9 (32%)	0.09
Male	60 (54%)	14 (43%)	46 (59%)		41 (49%)	19 (68%)	
Admitting Diagnosis (%yes)							
Other	9 (8%)	3 (9%)	6 (8%)	0.95	6 (7%)	3 (11%)	0.48
Cardiovascular	13 (12%)	2 (6%)	11(14%)		7 (8%)	6 (21%)	
Peripheral Vascular	5 (5%)	1 (3%)	4 (5%)		4 (5%)	1 (4%)	
Abdominal	16 (14%)	5 (15%)	11 (14%)		12 (14%)	4 (14%)	
Neurologic	27 (24%)	8 (24%)	19 (24%)		20 (24%)	7 (25%)	
Respiratory	9 (8%)	3 (9%)	6 (7%)		7 (8%)	2 (7%)	
Infection	11 (10%)	3 (9%)	8 (10%)		8 (10%)	3 (11%)	
Skeletomuscular	21 (19%)	8 (24%)	13 (17%)		19 (23%)	2 (7%)	
Charlson Co-Morbidity Score							
Mean	3.6 (2.7)	3.2 (2.3)	2.8 (2.9)	0.29	3.5 (2.8)	4.3 (2.2)	0.17
Median (range)	3.0 (0-15)						
≤3 comorbidities	58 (52%)	18 (55%)	40 (51%)		46 (55%)	12 (43%)	0.25
≥4 comorbidities	53 (48%)	15 (45%)	38 (49%)	0.75	37 (45%)	16 (57%)	
Unit of Origin							
ICU	44 (40%)	15 (45%)	29 (37%)	0.43	28 (34%)	16 (57%)	0.03
Non-ICU	67 (60%)	18 (55%)	49 (63%)		55 (66%)	12 (43%)	
MET-RD on Admission Day One (%yes)	48 (43%)	13 (39%)	35 (45%)	0.59	35 (42%)	13 (46%)	0.69
Respiratory Support upon arrival to RD % yes	72 (65%)	23 (72%)	45 (60%)	0.21	50 (62%)	18 (67%)	0.65
Nasal Cannula	41 (38%)	11 (10%)	30 (28%)	0.15	32 (30%)	9 (8%)	0.20
Face Mask	13 (12%)	4 (4%)	9 (8%)		11 (10%)	2 (2%)	
Ventilator	16 (15%)	8 (7%)	6 (6%)		7 (6%)	7 (6%)	
Cardiovascular Support prior to RD (%yes)	23 (25%)	8 (24%)	17 (22%)	0.78	14 (17%)	11 (39%)	0.02
Cardiac Arrhythmias prior to RD (%yes)	30 (27%)	11 (33%)	19 (24%)	0.33	26 (31%)	4 (14%)	0.09
Sedation prior to RD (%yes)	25 (23%)	9 (27%)	16 (21%)	0.44	19 (23%)	6 (21%)	0.87
VS 12 hours prior to RD Meets MET Criteria (%yes)	18 (16%)	3 (9%)	15 (19%)	0.26	13 (16%)	5 (18%)	0.77
Respiratory	5 (5%)	1 (3%)	4 (5%)	1.00	2 (2%)	3 (11%)	0.10
Heart Rate	2 (2%)	1 (3%)	1 (1%)	0.51	2 (2%)	0 (0%)	1.00
Systolic	10 (9%)	2 (6%)	8 (10%)	0.72	7 (8%)	3 (11%)	0.71
Diastolic	6 (5%)	0 (0%)	6 (8%)	0.18	5 (6%)	1 (4%)	1.00
Tachycardia	38 (34%)	13 (39%)	25 (32%)	0.46	31 (37%)	7 (25%)	0.26
Tachypnea							
Breaths ≥24 per min	31 (28%)	8 (24%)	23 (29%)	0.57	21 (25%)	10 (36%)	0.29
Breaths ≥30 per min	12 (11%)	1 (3%)	11 (14%)	0.09	8 (10%)	4 (14%)	0.49

Table 3. The total sample demographic and care requirement characteristics of 111 patients who required a Medical Emergency Team call to the radiology department (MET-RD) during their radiology care Intra-RD (Panel A), and comparisons of characteristics according to their outcomes of post-MET care requirement (Panel B) and mortality (Panel C).

Characteristics		Post MET-RD Patient Outcomes					
A. Intra-RD Patient Demographics and Care Requirements	n (%) Mean (\pm SD) n=111	B. Care Requirements			C. Mortality		
		Usual Care n=33	Higher Care n=78	p	Survival to Discharge n=83	Death n=28	p
Radiology Modality							
Computerized Tomography	49 (44%)	16 (48%)	33 (42%)	0.22	34 (41%)	15 (54%)	0.28
Magnetic Resonance Imaging	24 (22%)	5 (15%)	19 (24%)		20 (24%)	4 (14%)	
Interventional Radiology	14 (13%)	4 (12%)	10 (13%)		9 (11%)	5 (18%)	
General X-ray	14 (13%)	7 (21%)	7 (9%)		13 (16%)	1 (4%)	
Other (Nuclear Medicine, Peripheral Vascular, Ultrasound)	10 (9%)	1 (3%)	9 (12%)		7 (8%)	3 (11%)	
MET-RD Etiology (%yes)							
Cardiac	45 (41%)	16 (48%)	29 (37%)	0.41	34 (41%)	11 (39%)	0.86
Respiratory	32 (29%)	6 (18%)	26 (33%)		23 (27%)	9 (32%)	
Neurologic	28 (25%)	9 (27%)	19 (24%)		22 (21%)	6 (21%)	
Other	6 (5%)	2 (6%)	4 (5%)		4 (5%)	2 (7%)	
Sedation in RD (%yes)	18 (16%)	7 (21%)	11 (14%)	0.19	11 (13%)	7 (25%)	0.30
Monitor in the RD (%yes)	63 (57%)	18 (55%)	45 (58%)	0.76	42 (51%)	21 (75%)	0.02
RD Level of Surveillance							
RD Tech only	36 (40%)	13 (39%)	27 (35%)	0.49	36 (43%)	4 (15%)	0.04
RD RN	15 (14%)	6 (18%)	9 (12%)		11 (13%)	4 (15%)	
ICU/non-ICU RN	49 (43%)	14 (42%)	35 (45%)		33 (40%)	16 (59%)	
Advanced Patient Care Technician	5 (5%)	0 (0%)	5 (6%)		3 (4%)	2 (8%)	

5.2 DISCUSSION SPECIFIC AIMS 1 & 2

Our study found variations in the time, unit of origin, type of testing and vital sign alterations among the 111 patients who experienced a MET-RD over a two years period at a tertiary care academic hospital. MET-RD calls were concentrated in the daylight hours and during weekdays.

The majority of patients who experienced a MET-RD arrived from non-ICU units. CT scan had the highest percentage of MET-RD calls. Patients were noted to have documented alterations in vital signs, notably tachycardia and tachypnea, in the 12 hours prior to MET-RD. Over half of the MET-RD patients received continuously monitored of vital signs while in the RD. A large majority (70%) required a higher level of care post MET-RD and 25% died during hospitalization post MET-RD.

Our post MET-RD 25% in-hospital death rate exceeds that reported in the literature, which reports mortality rate of 11-19% (Chan et al., 2008; Smith & Wood, 1998). However, our MET-RD mortality rate is not that different from our previously reported inpatient MET-RD mortality rate of 21% (Ott, Hravnak, Clark & Amesur, in press), suggesting that mortality rate comparisons need to be hospital specific. Interestingly, of the 70% of patients requiring a higher level of care, only 34% required a higher acuity care unit; however 23% required post MET-RD procedures (27% to the operating room). Chen et al. (2008) reports only 46% requiring a higher level of care; however 45% of patients required a higher acuity care unit and only 0.6% requiring a procedure post MET on a general ward. The dramatic difference in outcome results may be due to the inclusion of ICU patients in our MET-RD sample. ICU patients arrive in the RD already critically ill and potentially having been sent to the RD due to deteriorating conditions. Despite the increased surveillance accompanying ICU patients to the RD (Ott, Hoffman & Hravnak, 2011) activation of the MET is needed in response to patient deterioration.

Charlson Comorbidity Index total scores ≥ 5 have been associated with high mortality and co-morbid related complications in hospitalized patients (Charlson, Pompei, Ales & MacKenzie, 1987; Chin & Goldman, 1997). The Charlson comorbidity index total scores (48% with CCI scores ≥ 4) may reflect on the 25% mortality seen in this sample. Compared to those

reported in other instability studies featuring non-ICU patients [Hravnak et al. (2008) 8.9% CI ≥ 4 , Capelastegui et al. (2008) 12.5% CCI ≥ 3 , Chin et al. (1997) 20% CCI ≥ 4] we noted is an increased comorbid burden in the MET-RD sample.

The diurnal variations in MET-RD calls noted in this study followed a pattern previously reported in the literature for other care areas, with the highest concentration of calls from 0800-1200 hours (representing the beginning of the daylight shift) and the majority of the calls on the weekdays (Schmid-Mazzoccoli, et al., 2008; Hravnak, et al., 2008; Galhotra et al., 2006). The RD procedural units at our study site serve both inpatients and outpatients, with outpatient procedures concentrated on weekdays. Potentially, the impact of outpatient demands may have influenced this finding; however, it may also have related to differences in acuity.

The most common radiologic modality for a MET-RD was CT (44%). Over half of the MET-RD patients who died during hospitalization (54%), experienced their MET-RD in CT. This is consistent with findings from our preliminary study in this institution (Ott, et al., in press) and with intrahospital transport literature (PA-PSRS, 2005). CT has been identified as both the area of highest patient volume and the area where patients are at the greatest risk for adverse events. From a review of 8 studies enrolling 650 patients who were transported for testing, Stevenson et al. (2002) reported that 50% involved the CT scanning area.

In a prospective study of 125 intrahospital transports of ICU patients, one third experienced an instability event that was potentially life-threatening, and the majority of these events (75%) occurred in the RD or the operating room (Smith & Wood, 1998). Equipment failure has been cited as a cause of adverse events during intrahospital transport of ICU patients to the RD, alterations in blood pressure, heart rate and oxygenation are also cited (Waydas, 1999). Patients often show signs of physiologic compromise hours before clinicians recognize

the need for rescue interventions (Hillman et al., 2001; Hillman et al., 2002; Schein, et al., 1990; Hravnak, et al., 2008). Therefore, we examined the recorded vital signs for all MET-RD patients in the 12 hours prior to the MET-RD call. A minority (16%) reached MET call vital signs threshold of concern in one or more of the vital sign parameters. Perhaps more importantly, there were signs of physiologic compromise in 34% of the patients with recorded heart rates >100 beat per min and 28% of the patients with recorded respiratory rates ≥ 24 breaths per min (11% ≥ 30 breaths per min). While not meeting the MET call threshold, these changes likely signaled physiological compromise. In prior studies a respiratory rate ≥ 24 breaths per min has been associated with critical illness (Cretikos, 2008) and ≥ 30 breaths per min has been predictive of higher acuity care needs and hospital mortality (Burch, 2008). Our study did not evaluate whether care was modified to manage these vital sign changes. Therefore, it is unknown whether preventive actions might have averted the MET-RD call. However, this finding reinforces the need to closely monitor vital signs and the importance of this parameter as a signal of compromise.

Interestingly, the majority of MET-RD patients were on continuous electronic vital sign monitors while in the RD and staff RNs from the general ward, resource pool or ICU accompanied 43% of the patients to the RD; only 8% of these were non-ICU patients. This suggests that the non-ICU patient acuity may be underestimated prior to transfer to the RD. When not accompanied by a staff RN, the technician responsible for conducting the radiologic scan was the only source of patient surveillance for 40% of the MET-RD patients. The RD RN (regular RD staff) provided surveillance for 14% of patients prior to the MET-RD call. In the study site, a 1:1 RD RN to patient ratio for direct nursing surveillance occurs only for select high risk procedures (i.e.: conscious sedation, lung biopsy) or when specific medications are required

per procedure protocol (i.e.: coronary artery CT angiography, cholescintigraphy). Although additional RN staff can be requested to respond to increased surveillance needs including instability, they must be requested by the technician or radiologist. Our findings did not allow us to determine if RD technicians did not recognize the instability or if the instability was of rapid onset precluding the technician calling for RD RN assistance in advance of activating the MET. Direct nursing surveillance of all patients in the RD is neither practical nor necessary. The challenge is to identify patients prior to the need for a MET call in order to better allocate resource to provide for optimal nursing surveillance. Our findings suggest that close monitoring of changes in heart and respiratory rate may provide important initial warning.

In this study, a cardiac MET etiology occurred most frequently (41%), which may in part be due to the comorbidity prevalence of myocardial infarct (21%) and cardiopulmonary disease (20%). In contrast, only a third of the MET call etiology was due to a respiratory cause, which is the most common reason for a MET call in general ward patients (Hodgetts, Kenward, Vlachonikolis, Payne & Castle, 2002; Jones et al., 2006). One explanation may be that, unlike the general ward MET studies, our sample includes ICU patients and 15% of our sample arrived in the RD already intubated and accompanied by a respiratory therapist per hospital policy. Downey et al. (2008) reported that a neurological etiology was the majority etiology and was significantly associated with hospital mortality of acute care patients. We did not find the type MET-RD etiologies to be significantly associated with need for post-MET higher level of care or mortality.

5.3 LIMITATIONS SPECIFIC AIMS 1 & 2

There are several limitations to our evaluation of specific aims 1 & 2. The single tertiary academic medical center with a well-established MET system may limit the generalizability of these findings to the in-patient populations seen by other radiology departments. Despite the two year time frame, the study enrolled a relatively small sample. The retrospective nature of the study required collection of data from a variety of existing data sources. We recognize that clinical data sources, such as the medical record, are not designed for research purposes, and missing or inconsistently recorded data may introduce threats to validity. Nevertheless, the findings suggest the need for further prospective studies in this area.

5.4 CONCLUSIONS SPECIFIC AIMS 1 & 2

The characteristics and outcomes of patients who experience a MET call while in the radiology department differ from those of patients who experience a MET on the general ward, both with regard to MET etiology and comorbidity burden. MET-RD patients are a mix of ICU and non-ICU patients who potentially have more complex clinical characteristics than general ward MET patients. Experiencing a MET call away from the usual hospital unit such as the RD may place patients at increased risk for a need for escalation of care or death. Transient care of patients outside of their usual care areas in the RD potentially places patients at risk. Improved mechanisms to identify at risk patients may improve the utilization of resource for nursing surveillance in the RD thus improving patient outcomes. Improved communication and handoff between the sending unit nurses and the RD nurses may increase the RD nurses' ability to

identify patient care needs, appropriate monitoring and surveillance. Further inquiry is needed to evaluate the variations between the ICU and non-ICU patients in the RD.

6.0 RESEARCH RESULTS AND DISCUSSION: SPECIFIC AIM 3

6.1 RESULTS SPECIFIC AIM 3

The event rate for MET-RD and MET-W was 0.42 and 0.31 events/hour/1000 RD admissions, respectively. There was no significant difference in the event rates of MET-RD and MET-W calls when adjusted for LOS ($p=0.74$). However, MET-RD and MET-W differed in pattern of occurrence (Table 4). While MET-W calls per month remain fairly consistent throughout the year, MET-RD calls decreased in July, August and November. RD admissions per month remained constant throughout the year with a slight increase in July and appeared to be unaffected by fluctuations in hospital admissions per month (Table 4). The average LOS-RD per month consistently remained less than one hour, with the average for the year of 58 minutes.

Within the RD (Table 5), the majority of MET-RDs occurred in CT (38%) with an average LOS of 47 min and an event rate (.94); this was more than twice the RD average. MRI represented only 5% of the RD admissions, but the average LOS in MRI (90 ± 34 minutes) was 1.5 times longer than the average LOS-RD and represented 27% of the MET-RD calls. The MRI event rate (1.43) was 3.5 times higher than the average RD event rate (.42). The longest LOS-RD was seen in NM (111 ± 58 minutes). Although NM represented only 1% of RD admissions and 5% of MET-RD calls, the event rate (1.34) was 3.2 times higher than the RD average. Four of the RD modalities (MRI, NM, CT, IR) had MET-RD event rates higher than the average MET-

RD and MET event rates (Figure 5). Analysis of event rates for the combined RD specialty modalities (minus XR) revealed an average RD specialty modality event rate that was significantly higher and more than three times the event rate of MET-W (0.76 v. 0.31, $p=.007$) (Figure 5).

6.2 DISCUSSION SPECIFIC AIM 3

The RD is known as a potentially high risk area, providing care for ICU and non-ICU patients who require procedures not available at the bedside. Given that patients spend days on their hospital units and only minutes or hours in the RD, greater risk for instability might be anticipated on general hospital units. However, our analysis of MET-RD and MET-W event rates found no significant difference, suggesting that MET events occur at the same rate regardless of patient location. This finding is consistent with literature concerning ICU patients. Studies comparing patients who are transported to the RD and those who remain in the ICU suggest that episodes of instability result from patient condition, not location (Hurst et al., 1992; Szem et al., 1995).

However, we did note significant differences in MET events between radiologic specialty modalities in the RD as compared to the hospital. When we looked at the MET-RD event rate for the specialty modalities (minus XR), the event rate was significantly higher than the MET-W ($p=.007$). CT was the highest MET-RD call area with 38% of all MET-RD calls originating in CT and a MET-RD event rate of 0.94 events/hour/1000 RD admissions. ICU patients are most frequently transported to the RD to obtain diagnostic information from a CT scan (Stevenson, Haas & Wahl, 2002; Waydas, 1999; PA-PSRS, 2005). One study reported that half of all

intrahospital transport of ICU patients was to CT (Stevenson, et al., 2002). Even though CT is often considered a safe option for critically ill patients, the average time required for this diagnostic test is 62-92 minutes (Stevenson, et al., 2002). Our study, including ICU and non-ICU patients, confirmed CT as a high volume procedure with 19% of all RD exams, second only to general radiology. Our length of stay in CT (42 ± 24 minutes) was less than reported in the literature. These differences may be related to the physical hospital layout or scheduling efficiency which can reduce patient wait time. Regardless, study data indicated that CT was a high volume modality with a shorter LOS-RD compared to other modalities.

In our study, patients experienced the highest MET-RD event rate during MRI. Although MRI represented only 5% of the RD volume; 27% of the MET-RD calls originated during a MRI. Additionally, during this procedure, patient LOS was double that for CT, suggesting that patients were at greater risk with a longer testing interval. If adverse events are a result of patient condition, an increased duration of time in the RD would logically increase risk of an adverse event. MRI patients may also be at increased risk for developing significant instability because the procedure does not allow the same level of monitoring and direct patient observation as other procedures because of the interference with the monitoring equipment by the magnetic field and the limited visibility of the patient while in the scanner bore.

Length of stay was longest in NM and IR. NM represented the lowest volume of patients and 5% of the MET-RD calls. The IR standard of care was a one-to-one nurse: patient ratio during all procedures. In addition to a dedicated nurse, an IR physician and IR technician were present for each procedure. Thus, IR had the highest level of patient surveillance which may explain the lower MET-RD event rate despite the second longest average length of stay (108 minutes). More research is needed to determine if an increased level of patient surveillance in

MRI, NM and CT would translate into lowered MET-RD event rates or if the different event rates reflect differing patient acuity and co-morbidities.

One to one nurse: patient monitoring is not practical or the best utilization of available resources for all RD patients. We know that the majority of patients remain stable throughout their hospitalization. Hravnak et al. reported that the majority of step down unit patients remain stable throughout their hospitalization with only 25% having episodes of instability during their hospital stay. The challenge is in identifying which patients are at greatest risk and require higher dedication of resources such as continuous monitoring and lower nurse: patient ratios. Since patients appear to be at the same risk of developing instability in the RD as on their unit, the most appropriate approach would be to provide (at a minimum) the same level of care and surveillance in the RD as expected on the unit. Since patients appear to be at increased risk when undergoing MRI, CT and NM, these patients may require a higher level of care and surveillance—a premise that requires further exploration.

Table 4. The medical emergency team calls in the Radiology Department (MET-RD) medical emergency team calls on the general ward (MET-W), admissions, incidence, length of stay and the event rates for MET-RD and MET.

2009 Months	MET-RD n=56 (%)	MET-W n=1553(%)	Radiology Admissions n=149,569 (%)	Hospital Admissions n=30,811 (%)	Incidence* of MET-RD	Incidence** of MET	Radiology Length of Stay (min)	Hospital Length of Stay (days)	Radiology MET-RD Event Rate†	Hospital MET Event Rate††
Jan	6 (11%)	167 (11%)	13,528 (9%)	2,955 (10%)	.44	60	58	6.6	.46	.38
Mar	5 (9%)	160 (10%)	13,969 (9%)	3,010 (10%)	.36	53	56	6.6	.39	.34
Apr	7 (13%)	156 (10%)	14,020 (9%)	2,930 (10%)	.50	50	57	6.5	.53	.32
May	8 (14%)	118 (8%)	13,866 (9%)	2,862 (9%)	.58	41	57	6.6	.61	.26
June	5 (9%)	100 (6%)	12,968 (9%)	2,788 (9%)	.39	36	59	6.5	.40	.23
July	2 (4%)	144 (9%)	14,710 (10%)	2,959 (10%)	.16	49	58	6.8	.16	.30
Aug	3 (5%)	110 (7%)	13,844 (9%)	2,814 (9%)	.22	39	57	6.5	.23	.25
Sept	6 (11%)	116 (7%)	12,632 (8%)	2,810 (9%)	.47	40	57	6.6	.49	.25
Oct	6 (11%)	161 (10%)	13,321 (9%)	2,878 (9%)	.45	56	58	6.7	.45	.33
Nov	3 (5%)	159 (10%)	13,025 (9%)	2,614 (8%)	.23	61	58	7.2	.24	.35
Dec	5 (9%)	164 (11%)	13,696 (9%)	2,191 (7%)	.37	75	60	7.0	.37	.45
Mean					.40	50	58	6.7	.42	.31
* $\frac{\text{\# MET-RD in 2009}}{\text{RD in-patient admissions in 2009}} \times 1000 = \text{incidence/1000 RD admissions}$					† $\frac{\text{incidence /1000 RD admissions}}{\text{average LOS in RD/60 minutes}} = \text{X events/hour/1000 RD admissions}$					
** $\frac{\text{\# MET in 2009}}{\text{Hospital admissions in 2009}} \times 1000 = \text{incidence/1000 Hospital admissions}$					†† $\frac{\text{incidence/1000 hospital admissions}}{\text{(average hospital LOS in days x 24 hour)}} = \text{X event/hour/1000 hospital admissions}$					

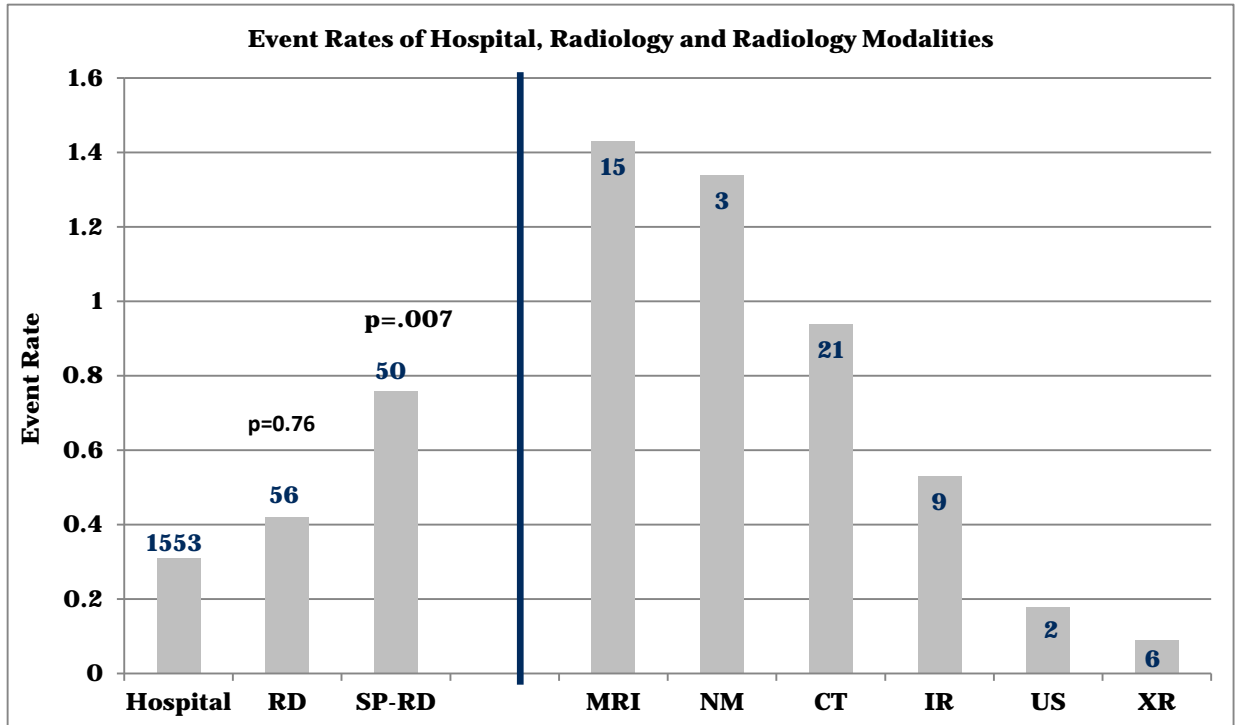
Table 5. The medical emergency team calls in the Radiology Department (MET-RD) per Radiology modality, Radiology admissions per modality, the incidence and event rates of MET-RD per modality.

	Radiology Patient Totals by Modality*	MET-RD Events	RD admissions	Incidence** of MET-RD	Radiology Length of Stay (min) Mean (±SD)	Event rate***
	n=19,377	n=56	n=149,569			
RD Modality n (%)						
Magnetic Resonance Imaging	1,824 (9%)	15 (27%)	6,962 (5%)	2.15	90 (34)	1.43
Nuclear Medicine	320 (2%)	3 (5%)	1,211 (1%)	2.48	111 (58)	1.34
Computed Tomography	4,835 (25%)	21 (38%)	28,453 (19%)	0.74	47 (24)	0.94
Interventional Radiology	1,952 (10%)	9 (16%)	9,409 (6%)	0.96	108 (46)	0.53
Ultrasound	2,377 (12%)	2 (4%)	9,928 (6%)	0.20	66 (27)	0.18
General X-Ray	8,069 (42%)	6 (11%)	93,606 (63%)	0.06	40 (29)	0.09

*Patient totals of those patients with complete intrahospital transport data used to calculate length of stay in Radiology.

** $\frac{\text{\# MET-RD in (RD Modality)}}{\text{RD in-patient admissions in (RD Modality)}} \times 1000 = \text{incidence/1000 RD Modality admissions}$

*** $\frac{\text{incidence/1000 RD modality admissions}}{\text{average LOS in RD modality/60 minutes}} = \text{X events/hour/1000 RD modality admissions}$



RD- Radiology Department, SP-RD – all RD modalities minus XR, MRI – magnetic resonance imaging, NM – nuclear medicine, CT- computed tomography, IR- interventional radiology, US- ultrasound, XR- general x-ray

Figure 5: Event Rates of medical emergency team calls on the Hospital general wards, the Radiology Department, Specialty modalities and the breakdown of event rates by Radiology modality

6.3 LIMITATIONS SPECIFIC AIM 3

There are several limitations to the evaluation of specific aim #3. The study was conducted in an academic medical center with a well-established MET system and therefore may not be representative of other settings. The retrospective methodology required collection of data from databases that were not designed for this purpose and we were required to develop processes to account for missing data which may have led to misinterpretation. Comparison of hospital and RD event rates comparisons are limited by the aggregate level hospital data. Because we do not have individual patient data for the hospital, the number of MET calls was standardized by

length of stay for comparison with MET-RD calls. In doing so, we made the assumption that the event rates are uniformly distributed across length of stay and in clinical practice this may not be the case. Findings of this study must therefore be considered preliminary.

6.4 CONCLUSIONS SPECIFIC AIM 3

These findings suggest that patients were at equal risk for experiencing a MET call in the RD as on a hospital unit. Therefore, the same level of monitoring and clinical care should be provided while patients are being transported to the RD as available on the clinical unit. Our data also suggested that MET-RD event rates are not evenly distributed across RD modalities. Patients appeared to be greater risk for a MET-RD call if schedule for a MRI, CT or NM scan. Clinicians sending patients to MRI, NM, and CT should recognize that patients are at increased risk for a MET and establish a plan for patient surveillance and care to improve patient safety. Our findings, if confirmed in other settings, have the potential to influence utilization of resources within the RD and the establishing standard of care relating to patient transport and monitoring, including the appropriate level of clinically skilled caregivers to monitor patients while in the RD.

6.5 FINAL IMPLICATIONS

To our knowledge this is the largest study of patient instability in the RD. We have identified several important findings related to the characteristics of patients who become unstable and

require a MET while in the RD, as well as, care areas in the RD where patients may be in need of increased surveillance. This work will serve to inform further research exploring the patient experience in the RD and interventions that may change nursing practice in the RD.

APPENDIX A- QUALITY IMPROVEMENT APPROVAL

**UPMC Health System
Quality Improvement Projects vs. Research Studies
Quality Improvement Review Screening Tool**

Date of Submission: 7/21/2009

Title of Project: Failure to Rescue: Patient Instability in the Radiology Department

Sponsor: Nikhil Amesur MD/Lora Ott RN, MSN **Department:** Imaging Services

Co-Sponsors: Marlon Johnson RN, Marilyn Hravnak PhD CRNP

Facility(UPMC entity): Presbyterian Hospital

Anticipated Start Date: 9/1/2009

Anticipated End Date: 12/31/2010

Estimated Duration of Entire Project: 18 months

Referred for QI review by IRB staff YES NO

1. Goal(s) of project: The purpose of this proposed QI project is to describe the incidence of MET events in the Radiology Department of UPMC Presbyterian Hospital, examine the selected modifiable and non-modifiable patient and surveillance characteristics associated with MET activation and compare the characteristics of patients who have good and poor outcomes following MET activation. The information gathered would then provide valuable information regarding patient instability in the Radiology Department that could then influence quality improvements, staff education, patient surveillance, early detection of patient instability and ultimately improve patient outcomes.

2. Is there a commitment to implementing a corrective plan based on the outcomes of the project (check one)?

No Yes

If "Yes" describe in brief.

With the information gathered if indicated policies regarding in-patient scheduling and imaging will be reviewed for quality improvement changes. Staff education regarding at risk patient characteristics, surveillance and early detection of patient instability will be implemented.

3. Is the project being funded by an external agency (check one)?

No Yes if yes, specify agency:

4. What is the primary intent of the project (answer one):

Publication or Quality Improvement

What improvements do you hope to implement in the local environment?

Patient safety improvement through policy change, staff education and patient appropriate surveillance. Improved screening and identification of the at-risk patients that will lead to early detection of patient instability and improved outcomes for patients in the Radiology Department who experience a MET activation.

- 5. If patient data is being collected, please indicate how data is going to be collected** (check all that apply and Circle the Database being used):

Chart review through medical records (*i.e.*, Horizon Patient Folder(HPF) and hardcopy records)

Chart review through electronic medical records (*i.e.*, Powerchart™, MARS, Stentor™ OR Other – please specify database):

Data collection from the UPMC Network Cancer registry database .(If using other registry database - Please specify database):

Patient interviews/observations

Please attach a sample data collection form. See attached

All patient identifiable data collected and stored for this study needs to comply with UPMC Policy HS MR1000 regarding the privacy and security of clinical data.

- 6. Provide a brief summary (one page) or abstract of your proposed project and attach it to this page. Attached**

- 7. If the project involves a therapeutic intervention, is the intervention to be delivered in a blinded fashion?** NA no intervention No Yes

- 8. Does the project involve “withdrawing” or holding back any needed and generally accepted treatments for the patients’ condition:** NA

No Yes

- 9. Does the project involve prospective assignment of patients to different procedures or therapies based on predetermined plans such as randomization?** NA

No Yes

- 10. Is the project evaluating a drug, biologic or device which is not currently FDA approved (*i.e.*, off label use)?** NA No Yes

- 11. Are Patients involved in the project exposed to additional risks or burdens (*i.e.* Other than the completion of patient satisfaction surveys) beyond standard clinical practice**

No Yes

12. What outcomes are being evaluated?

See attached list of variables

13. Describe briefly why you think this is a QI project and not a Research study:

This proposed project will provide valuable information regarding patient safety to the Radiology Department and, in areas for improvement are identified, may lead to improved patient care, policy change and quality improvement.

-

For completion by QI Review Committee designee:

Date of Review: Aug. 4, 2009

Date Approved: Aug. 12, 2009

Approved as Quality Improvement Project - YES

Agree: X

Disagree:

Date to be presented to Total Quality Council: Aug. 2009

Prospective date for feedback to TQC on outcomes: End of study

Comments: This retrospective review of Medical emergency incidents in Radiology aimed at reducing the number of such events and improving patient safety while in Radiology is approved as a QI project.

QI Review Number:0000362

Completed by:Dr.J.Jegasothy

Failure to Rescue: Patient Instability in the Radiology Department

Project Variables and Databases

Project Variables	MERIT	MARS	RAD Assessment	Paper Chart
age	X	X	X	X
gender	X	X	X	
race	X	X		
Admitting diagnosis	X	X		
Unit of origin	X	X	X	X
Radiology modality	X	X	X	X
Co-morbidity index		X		
intubation	X	X		
Drugs upon arrival to the RD		X		
Sedation upon arrival to the RD		X		
Vital Signs recorded in the RD			X	X
Movement across MET criteria	X	X	X	X
Drug infusion during procedure			X	X
Sedation during procedure			X	X
Oxygen use during procedure			X	X
Method of Monitoring			X	X
Level of Surveillance			X	X
Diurnal variation	X			
Survival to Discharge		X		
Higher level of care required	X	X		

Project Variable Definitions

Incidence of MET in hospitalized in-patients in the RD and Incidence of MET in Hospitalized in-patients. The incidence of MET activations for hospitalized in-patients in the RD will be measured as the number of MET activations in the RD for patients whose unit of origin is an in-patient unit per 1000 in-patient procedures performed in the RD. The incidence of MET activations in hospitalized in-patients will be measured as the number of MET activations for in-patients per 1000 in-patient admissions.

Non-modifiable patient characteristics:

Those patient characteristics that cannot be modified by policy change or practice improvements within the RD: age, gender, race, admitting diagnosis, unit of origin: medical, surgical, step-down, intensive care unit; radiology modality where the procedure is performed: Magnetic Resonance Imaging (MRI), Computerized Tomography (CT), Ultrasound (US), Nuclear Medicine(NM), Peripheral Vascular (PV), Interventional Radiology (IR), Fluoroscopy (Fluoro), General X-ray (X-ray); co-morbidity index, intubation: yes/no, drug infusions upon arrival to the RD: cardiovascular support medication for blood pressure management, volume expansion, cardiac arrhythmias; sedation upon arrival to the RD: intravenous(IV) lorazepam or propofol.

Modifiable patient characteristics: Those patient characteristics that can be modified by policy change or practice improvement within the RD: vital signs recorded in the RD: heart rate (HR), blood pressure (BP), oxygen saturation (SpO₂); movement across MET activation threshold criteria, drug infusion during procedure: IV contrast dye, pain medication, cardiovascular support medication for blood pressure management, volume expansion, cardiac arrhythmias; sedation during procedure: IV ativan, propofol, conscious sedation, general anesthesia; supplemental oxygen during procedure: the use of oxygen to maintain a SpO₂ greater than 92% oxygen saturation.

Modifiable surveillance characteristic:

Those surveillance characteristics that can be modified by policy change or practice improvements within the RD: method of monitoring: any combination of cardiac monitor, SpO₂, BP or no monitoring; level of surveillance: patient is monitored during the procedure by a staff RN, radiology RN, patient care technician trained to read cardiac monitors (APCT), or the radiology technician performing the procedure only; diurnal variation.

Patient Outcome:

Survival to discharge: comparison of patient mortality to those patients that survive to be discharged from the hospital post MET activation in the RD. Higher level of care required: increased respiratory support (increased supplemental oxygen, hi-flow oxygen delivery system, increased ventilator settings, endotracheal intubation) increased vasoactive drug infusion, volume resuscitation, transfer for procedure or surgery, transfer to a hospital unit with a higher level of monitoring than the unit of origin.

MET activation criteria for UPMC Presbyterian Hospital: The institution specific criteria designating when to summon the MET team are as follows:

Respiratory Rate: <8/min or >36/min, new onset difficulty breathing, new SpO₂ <85% for > 5 min (unless known chronic hypoxemia), new requirement for >50% O₂ to maintain SpO₂ > 85%

Heart Rate: <40 or >140 bpm with new symptoms; any rate >160 bpm

Blood Pressure: systolic <80 or >200 mm Hg, diastolic >110 mm Hg with symptoms (neurologic changes, chest pain, and dyspnea)

Neurologic Change: Loss of Consciousness, new onset lethargy, sudden loss of mobility of face, arm or leg, sudden collapse, seizure (outside seizure monitoring unit)

Other Criteria: >1 STAT page required to assemble team needed to respond to a crisis, patient complaint of (cardiac) chest pain (unresponsive to nitroglycerine, or MD unavailable, color change (of patient or extremity): pale, dusky, gray or blue, unexplained agitation of > 10 min, suicide attempt, bleeding into airway, Narcan use without immediate response, uncontrolled bleeding, large acute blood loss, crash cart must be used for rapid delivery of meds

APPENDIX B - IRB APPROVAL LETTER



University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)
<http://www.irb.pitt.edu>

Memorandum

To: [Lora Ott](#), RN, MSN
From: [Sue Beers](#), PhD, Vice Chair
Date: 3/24/2011
IRB#: [REN11030171](#) / PRO10040043
Subject: Medical Emergency Teams in the Radiology Department: Patient Characteristics and Outcomes

Your renewal for the above referenced research study has received expedited review and approval from the Institutional Review Board under: **This approval is for the analyzation of data only.**

45 CFR 46.110.(5) clinical data

Please note the following information:

Approval Date: 3/24/2011
Expiration Date: 3/23/2012

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. The IRB Reference Manual (Chapter 3, Section 3.3) describes the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least **one month** prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

APPENDIX C - NIH NINR FUNDING LETTER



Grant Number: 1F31NR012343-01

Principal Investigator(s):

Lora K. Ott

Project Title: Failure to Rescue: Patient Instability in the Radiology Department

Mr. Paul Karas
University of Pittsburgh
Office of Research
123 University Place
Pittsburgh, PA 15213

Award e-mailed to: ornih@offres.pitt.edu

Latest Activation Date: 11/26/2010

Dear Business Official:

The National Institutes of Health hereby awards a grant in the amount of \$41,380 (see "Award Calculation" in Section I and "Terms and Conditions" in Section III) to UNIVERSITY OF PITTSBURGH AT PITTSBURGH in support of the above referenced project. This award is pursuant to the authority of 42 USC 288 42 CFR 66 and is subject to the requirements of this statute and regulation and of other referenced, incorporated or attached terms and conditions.

Acceptance of this award including the "Terms and Conditions" is acknowledged by the grantee when funds are drawn down or otherwise obtained from the grant payment system.

Each publication, press release or other document that cites results from NIH grant-supported research must include an acknowledgment of NIH grant support and disclaimer such as "The project described was supported by Award Number F31NR012343 from the National Institute Of Nursing Research. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute Of Nursing Research or the National Institutes of Health."

Award recipients are required to comply with the NIH Public Access Policy. This includes submission to PubMed Central (PMC), upon acceptance for publication, an electronic version of a final peer-reviewed, manuscript resulting from research supported in whole or in part, with direct costs from National Institutes of Health. The author's final peer-reviewed manuscript is defined as the final version accepted for journal publication, and includes all modifications from the publishing peer review process. For additional information, please visit <http://publicaccess.nih.gov/>.

Award recipients must promote objectivity in research by establishing standards to ensure that the design, conduct and reporting of research funded under NIH-funded awards are not biased by a conflicting financial interest of an Investigator. Investigator is defined as the Principal Investigator and any other person who is responsible for the design, conduct, or reporting of NIH-funded research or proposed research, including the Investigator's spouse and dependent children. Awardees must have a written administrative process to identify and manage financial conflict of interest and must inform Investigators of the conflict of interest policy and of the Investigators' responsibilities. Prior to expenditure of these awarded funds, the Awardee must report to the NIH Awarding Component the existence of a conflicting interest and within 60 days of any new conflicting interests identified after the initial report. Awardees must comply with these and all other aspects of 42 CFR Part 50, Subpart F. These requirements also apply to subgrantees, contractors, or collaborators engaged by the Awardee under this award. The NIH website <http://grants.nih.gov/grants/policy/coi/index.htm> provides additional information.

If you have any questions about this award, please contact the individual(s) referenced in Section IV.

Sincerely yours,

Brian Albertini
Grants Management Officer
NATIONAL INSTITUTE OF NURSING RESEARCH

Additional information follows

SECTION I – AWARD DATA – 1F31NR012343-01**Award Calculation (U.S. Dollars)**

Other Fellowship Expenses	\$16,000
Institutional Allowance	\$4,200
Stipends	\$21,180

Federal Direct Costs	\$41,380
Total Award	\$41,380
Federal Share	\$41,380
TOTAL FEDERAL AWARD AMOUNT	\$41,380

AMOUNT OF THIS ACTION (FEDERAL SHARE) \$41,380

SUMMARY TOTALS FOR ALL YEARS		
YR	THIS AWARD	CUMULATIVE TOTALS
1	\$41,380	\$41,380
2	\$41,380	\$41,380
3	\$41,380	\$41,380

Recommended future year total cost support, subject to the availability of funds and satisfactory progress of the project

Fiscal Information:

CFDA Number: 93.361
EIN: 1250965591A6
Document Number: FNR012343A
Fiscal Year: 2010

IC	CAN	2010	2011	2012
NR	8472505	\$41,380	\$41,380	\$41,380

Recommended future year total cost support, subject to the availability of funds and satisfactory progress of the project

NIH Administrative Data:

PCC: DTRHC / **OC:** 412L / **Processed:** ALBERTINIB 05/24/2010

Fellow's e-mail:

Lora K. Ott ottl@pitt.edu

SECTION II – PAYMENT/HOTLINE INFORMATION – 1F31NR012343-01

For payment and HHS Office of Inspector General Hotline information, see the NIH Home Page at <http://grants.nih.gov/grants/policy/awardconditions.htm>.

SECTION III – TERMS AND CONDITIONS – 1F31NR012343-01

This award is based on the application submitted to, and as approved by, NIH on the above-titled project and is subject to the terms and conditions incorporated either directly or by reference in the following:

- The grant program legislation and program regulation cited in this Notice of Research Fellowship Award.

- b. Conditions on activities and expenditure of funds in other statutory requirements, such as those included in appropriations acts.
- c. The NIH Grants Policy Statement, including addenda in effect as of the beginning date of the budget period.
- d. This award notice, INCLUDING THE TERMS AND CONDITIONS CITED BELOW.

(see NIH Home Page at '<http://grants.nih.gov/grants/policy/awardconditions.htm>' for certain references cited above.)

In accordance with P.L. 110-161, compliance with the NIH Public Access Policy is now mandatory. For more information, see NOT-OD-08-033 and the Public Access website: <http://publicaccess.nih.gov/>.

An Activation Notice (PHS 416-5) must be submitted to the NIH awarding office as of the day the fellow begins training. Submission of a Payback Agreement form is also required for postdoctoral fellows in their first 12 months of Kirschstein-NRSA postdoctoral support. A payback agreement does not apply to predoctoral support. The applicable forms should be submitted to the awarding component at the following address:

National Institute of Nursing Research
6701 DEMOCRACY BLVD, RM 710
One Democracy Plaza
Bethesda, MD 20892-4870
Bethesda, MD: Maryland 20892

The Activation Notice and Payback Agreement forms are available at the following websites: <http://grants1.nih.gov/grants/funding/416/phs416-5.pdf> and <http://grants1.nih.gov/grants/funding/416/phs6031.pdf>

No funds can be disbursed until an activation notice and a payback agreement, if applicable, are submitted to the NIH. This award should be activated within six months, in accordance with the latest activation date.

Fellows are required to notify the awarding unit as soon as they are aware of any possible change in plans regarding their fellowship support.

SECTION IV – NR Special Terms and Conditions – 1F31NR012343-01

INFORMATION: FELLOWSHIP ACTIVATION NOTICE

This award may not be activated from October 1 through November 15 or prior to the issue date of this Notice of Fellowship Award.

INFORMATION: STIPENDS

In accordance with NIH Guide Notice NOT-OD-10-047, this award reflects the stipend level for predoctoral trainees for FY2010, as published in the NIH Guide Notice, Ruth L. Kirschstein National Research Service Award (NRSA) Stipend and Other Budgetary Levels Effective for Fiscal Year 2010. (<http://grants.nih.gov/grants/guide/notice-files/NOT-OD-10-047.html>).

INFORMATION: TUITION AND FEES ADJUSTMENT

The Tuition and Fees Category for competing awards is calculated in accordance with the NIH Guide Notice NOT-OD-10-047 (<http://grants.nih.gov/grants/guide/notice-files/NOT-OD-10-047.html>). No future year escalation is provided.

INFORMATION: STIPEND SUPPLEMENTATION

Stipend supplementation and compensation policies must be followed as described in the NIH Grants Policy Statement, December 1, 2003. National Institute of Nursing Research considers limited part-time to be no more than ten hours per week in addition to the full-time fellowship training.

INFORMATION: EMPLOYMENT

Since NRSA awards are not provided as a condition of employment with either the Federal Government or the grantee institution, it is inappropriate and unallowable for institutions to seek funds for or to charge individual fellowship grant awards for costs that would normally be associated with employee benefits (for example: FICA, worker's compensation, and unemployment insurance.)

INFORMATION: INSTITUTIONAL ALLOWANCE

The institutional allowance is provided to help defray expenses as research supplies, equipment, travel to scientific meetings, and health insurance. Funds are paid directly to and administered by the sponsoring institution.

INFORMATION: FELLOWSHIP EXPENSES

"Other fellowship expenses" are provided to help cover a portion of tuition and fees.

INFORMATION: DOCTORAL DEGREE

This award may not continue beyond the completion of all doctoral degree requirements.

INFORMATION: PAYBACK

Section 1602 of the NIH Revitalization Act eliminated the payback obligation for pre-doctoral individuals. Therefore, it is not necessary for a Payback Agreement to be completed, and most of the terms discussed in the NRSA Assurance contained in the application that you submitted are no longer relevant. However, Item V. Program Evaluation is still applicable, i.e., "I understand that I may also be contacted from time to time, but no more frequently than once every two years, after the termination of this award to determine how the training obtained has influenced my career. Any information thus obtained would be used only for statistical purposes and would not identify me individually."

INFORMATION: FELLOWSHIP EARLY TERMINATION

Should this fellowship terminate before the reflected budget/project period end date, submit a Termination Notice (PHS 416-7) and attach a categorical breakdown (stipends, institutional allowance, tuition, and travel) expended on this award.

STAFF CONTACTS

The Grants Management Specialist is responsible for the negotiation, award and administration of this project and for interpretation of Grants Administration policies and provisions. The Program Official is responsible for the scientific, programmatic and technical aspects of this project. These individuals work together in overall project administration. Prior approval requests (signed by an Authorized Organizational Representative) should be submitted in writing to the Grants Management Specialist. Requests may be made via e-mail.

Grants Management Specialist: Randi Freundlich
Email: freundlichr@mail.nih.gov **Phone:** (301) 594-5974

Program Official: David Banks
Email: banksdh@mail.nih.gov **Phone:** 301-496-9558 **Fax:** 301-480-8260

SPREADSHEET SUMMARY

GRANT NUMBER: 1F31NR012343-01

INSTITUTION: UNIVERSITY OF PITTSBURGH AT PITTSBURGH

<i>Budget</i>	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>
---------------	---------------	---------------	---------------

Other Fellowship Expenses	\$16,000	\$16,000	\$16,000
Institutional Allowance	\$4,200	\$4,200	\$4,200
Stipends	\$21,180	\$21,180	\$21,180
TOTAL FEDERAL DC	\$41,380	\$41,380	\$41,380
TOTAL FEDERAL F&A			
TOTAL COST	\$41,380	\$41,380	\$41,380

BIBLIOGRAPHY

- Aiken, L., Sloane, D., Lake, E., Sochalski, J., & Weber, A. (1999). Organization and Outcomes of Inpatient AIDS Care. *Medical Care*, 37, 760-772.
- Aiken, L., Clarke, S., & Sloane, D. (2002). Hospital staffing, organization, and quality of care: cross-national findings. *International Journal for Quality in Health Care*, 14, 5-13.
- Aiken, L., Clarke, S., Sloane, D., Sochalski, J., & Silber, J. (2002). Hospital Nurse Staffing and Patient Mortality, Nurse Burnout, and Job Dissatisfaction. *Journal of American Medical Association*, 288(16), 1987-1993.
- Aiken, L., Clarke, S., Sloan, D., Lake, E., & Cheney, T. (2008). Effects of Hospital Care Environment on Patient Mortality and Nurse Outcomes. *Journal of Nursing Administration*, 38, 223-229.
- Bellomo, R., Goldsmith, D., Uchino, S., Buckmaster, J., Hart, G., Opdam, H., et al. (2004). Prospective controlled trial of the effect of medical emergency team on postoperative morbidity and mortality rates. *Critical Care Medicine*, 32, 916-921.
- Berwick, D.M., Calkins, D.R., McCannon, C.J., & Hackbarth, A.D. (2006). The 100,000 lives campaign: setting goals and a deadline for improving health care quality. *Journal of American Medical Association*, 295(3), 324-327.
- Bursch, V., Tarr, G., & Morroni, C. (2008). Modified early warning score predicts the need for hospital admission and in-hospital mortality. *Emergency Medical Journal*, 25, 674-678.

- Bobay, K., Fiorelli, K., & Anderson, A. (2008). Failure to Rescue a Preliminary Study of Patient-Level Factors. *Journal of Nursing Care Quality*, 23, 221-215.
- Brennan, T., Leape, L., Laird, N., Hebert, L., Localio, R., Lawthers, A., et al. (1991). Incidence of negligence and adverse events in hospitalized patients: Results of the Harvard Medical Practice study. *New England Journal of Medicine*, 324, 370-376.
- Buist, M., Harrison, J., Abaloz E., & Van Dyke, S. (2007). Six year audit of cardiac arrests and medical emergency team calls in an Australian outer metropolitan teaching hospital. *British Medical Journal*, 335, 1210-1212.
- Calzavacca, P., Licari, E., Tee, A., Moritoki, E., Haase, M. Haase-Fielitz, A., et al. (2008). A prospective study of factors influencing the outcome of patients after a Medical Emergency Team review. *Intensive Care Medicine*, 34, 2112-2116.
- Cardoso, C., Crion, C., Matsuo, T., Anami, E., Kauss, I., Seko, L., et al. (2011). Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. *Critical Care*, 15, R28 <http://ccforum.com/content/15/1/R28>.
- Capelastegui, A., Espana, P., Bilbao, A., Martinez-Vazquez, M., Gorordo, I., Oribe, M., et al. (2008). Pneumonia: Criteria for patient instability on hospital discharge. *Chest*, 134, 595-600.
- Chan, P., Khalid, A., Longmore, L., Berg, R., Kosiborod, R., & Spertus, J. (2008). Hospital-wide Code Rates and Mortality Before and After Implementation of a Rapid Response Team. *Journal of the American Medical Association*, 300 (21), 2506-2513.
- Chan, P., Renuks, J., Brahmajee, N., Berg, R., & Sasson, C. (2010). Rapid Response Teams A systematic Review and Meta-analysis. *Archives of Internal Medicine*, 170(1), 18-26.

- Chen, J., Bellomo, R., Flabouris, A., Hillman, K., & Finfer, S. (2009). The relationship between early emergency team calls and serious adverse events. *Critical Care Medicine*, 37, 143-153.
- Chen, L., Lu, K., Wo, C., & Shoemaker, W. (2007). Hemodynamic Patterns Preceding Circulatory Deterioration and Death After Trauma. *The Journal of TRAUMA Injury, Infection and Critical Care*, 62, 928-932.
- Chin, M., & Goldman, L. (1997). Correlates of early hospital readmission or death in patients with congestive heart failure. *American Journal of Cardiology*, 79, 1640-1644.
- Charlson, M., Pompei, K., Ales, K., & MacKenzie, C.R. (1987). A new method of classifying Prognostic Comorbidity in longitudinal studies: development and validation. *Journal of Chronic Disease*, 40(5), 373-383.
- Cretikos, M., Bellomo, R., Hillman, K., Chen, J., Finfer, S., & Flabouris, A. (2008). Respiratory rate: the neglected vital sign. *Medical Journal of Australia*, 188(11), 657-658.
- Clarke, S., & Aiken, L. (2003). Failure to Rescue, Needless deaths are prime examples of the need for more nurses at the bedside. *American Journal of Nursing*, 103, 42-47.
- Clarke, SP. (2004). Failure to rescue: lessons from missed opportunities in care. *Nursing Inquiry*, 11, 67-71.
- Clarke, SP. (2007). Nurse Staffing in Acute Care Settings: Research Perspectives and Practice Implications. *Joint Commission Journal on Quality and Patient Safety*, 33, 30-44.
- Clarke, SP. (2009). Three metaphors and a (mis)quote: thinking about staffing-outcomes research, health policy and the future of nursing. *Journal of Nursing Management*, 17, 151-154.

- Committee on Quality of Health Care in America, Institute of Medicine: *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001.
- DeVita, M., Braithwaite, R., Mahidhara, R., Stuart, S., Foraida, M., & Simmons, R. (2004). Use of medical emergency team responses to reduce hospital cardiopulmonary arrests. *Quality & Safety in Health Care*, 13, 251-254.
- DeVita, M., Bellomo, R., Hillman, K., Kellum, J., Rotondi, A., Teres, D., et al. (2006). Findings of the first consensus conference on Medical Emergency Teams. *Critical Care Medicine*, 34(9), 2463-2478.
- Deyo, R., Cerkin, D., & Ciol, M. (1992). Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *Journal of Clinical Epidemiology*, 45, 613-619.
- Downey, A., Quach, J., Haase, M., Haas-Fielitz, A., Joes, D., & Bellomo, R. (2008). Characteristics and outcomes of patients receiving a medical emergency team review of acute change in conscious state or arrhythmias. *Critical Care Medicine*, 36(2), 477-481.
- Galhotra, S., DeVita, M., Simmons, R., & Schmid, A. (2006). Impact of patient monitoring on the diurnal pattern of medical emergency team activation. *Critical Care Medicine*, 34(6), 1700-1706.
- Galhotra, S., DeVita, M., Simmons, R., Dew, M., & members of the Medical Emergency Response Improvement Team (MERIT) Committee (2007) Mature rapid response system and potentially avoidable cardiopulmonary arrests in hospital. *Quality & Safe Health Care*, 16, 260-265.
- Goldhill, D.R., White, S.A., & Sumner, A. (1999). Physiological values and procedures in the 24 h before ICU admission from the ward. *Anaesthesia*, 54, 529-34.

- Hall, W., Ramachandran, R., Narayan, S., Jani, A., & Vijayakumar, S. (2004). An electronic application for rapidly calculating Charlson comorbidity score. *BioMed Central Cancer*, 4, 94.
- Hillman, K., Bristow, P., Chey, T., Daffurn, K., Jacques, T., Norman, S.L., et al. (2001). Antecedents to hospital deaths. *Internal Medicine Journal*, 31, 343–8.
- Hillman, K., Bristow, P., Chey, T., Daffurn, K., Jacques, T., Norman, S.L., et al. (2002). Duration of life-threatening antecedents prior to intensive care admission. *Intensive Care Medicine*, 28:1629–34.
- Hillman, K., Chen, J., Cretikos, M., Bellomo, B., Brown, D., Doig, G., et al. (2005). Introduction of the medical emergency team (MET) system: a cluster randomised controlled trial. *Lancet*, 365, 2091-2097.
- Hodgetts, T., Kenward, G., Vlachonikolis, I., Payne, S., & Castle, N. (2002). The identification of risk factors for cardiac arrest and formulation of activation criteria to alert a medical emergency team. *Resuscitation*, 54, 125-131.
- Hravnak, M., DeVita, M., Edwards, L., Clontz, A., Valenta, C., & Pinsky, M. (2008). Defining the incidence of cardio-respiratory instability in step-down unit patients using an electronic integrated monitoring system. *Archives of Internal Medicine*, 168, 1300-1308.
- Hravnak, M., DeVita, M., Edwards, L., Clontz, A., Valenta, C., & Pinsky, M. (2008). Cardiorespiratory instability before and after implementing an integrated monitoring system. *American Journal of Respiratory and Critical Care Medicine*, 177, A842. Presented at American Thoracic Society Meeting, May 21, 2008; Toronto ON

- Hravnak, M., Schmid, A., Ott, L., & Pinsky, M. (2011). Causes of Failure-to-Rescue. In DeVita, Bellomo & Hillman (Eds) *Rapid Response Systems: Concept and Implementation*. New York, Springer
- Hurst, J., Davis, K., Johnson, D., Branson, R., Campbell, R., & Branson, P. (1992). Cost and complications during in-hospital transport of critically ill patients: a prospective cohort study. *Journal of Trauma*, 33(4), 582-585.
- Jolley, J., Bendyk, H., Holaday, B., Lombardozzi, K., & Harmon, C. (2007). Rapid Response Teams Do They Make a Difference? *Dimensions in Critical Care Nursing*, 26, 253-260.
- Jones, D., Duke, G., Green, J., Briedis, J., Bellomo, R., Casamento, A., et al. (2006). Medical Emergency Team syndromes and an approach to their management. *Critical Care*. 10, R30.
- Kern, J., & Shoemaker, W. (2002). Meta-analysis of hemodynamic optimization in high-risk patients. *Critical Care Medicine*, 30, 1686-1691.
- Leape, L., & Berwick, D. (2005). Five Years After to Err is Human, What Have We Learned? *Journal of American Medical Association*, 293, 2384-2390.
- Needham, D., Scales, D., Laupacis, A., & Pronovost P. (2005). A systematic review of the Charlson comorbidity index using Canadian administrative databases: a perspective on risk adjustment in critical care research. *Journal of Critical Care*, 20, 12-19.
- Needleman, J., & Buerhaus, P. (2007). Failure-to-rescue: Comparing definitions to measure quality of care. *Medical Care*, 45, 913-915.
- Peberdy, M., Cretikos, M., Abella, B., DeVita, M., Goldhill, D., Kloeck, W., et al. (2007). Recommended Guidelines for Monitoring, Reporting, and Conducting Research on Medical Emergency Team, Outreach, And Rapid Response Systems: An Utstein-Style Scientific Statement. *Circulation*, 116, 2481-2500.

- Quan, H., Parsons, G., & Ghali, W. (2002). Validity of information on comorbidity derived from ICD-9-CCM administrative data. *Medical Care*, 40, 675-685.
- Ott, L., Hravnak, M., Clark, S., & Amesur, N. (in press). Describing Patient Instability, Emergency Response and Outcomes in the Radiology Department: A Pilot Study. *American Journal Critical Care*.
- Ott, L., Hoffman, L., & Hravnak, M. (2011). Intrahospital Transport to the Radiology Department: Risk for Adverse Events, Nursing Surveillance, Utilization of a MET and Practice Implications. *Journal of Radiology Nursing*, 30, 49-54.
- Pennsylvania Patient Safety Authority. (2005). Is CT a high-risk area for patient transport? *PA-PSRS Patient Safety Advisory*, 2(3).
- Pennsylvania Patient Safety Authority. (2009). Safe intrahospital transport of the non-ICU patient using standardized handoff communication. *PA-PSRS Patient Safety Advisory*, 6(1).
- Prosser, J., MacGregor, L., Lees, K., Diener, H., Hacke, W., & Davis, S. (2007). Predictors of Early Cardiac Morbidity and Mortality after Ischemic Stroke. *Stroke*, August, 2295-2302.
- Ranji, S., Auerbach, A., Hurd, J. O'Rourke, K., & Shojanian, K. (2007). Effects of Rapid Response Systems on Clinical Outcomes: Systematic Review and Meta-Analysis *Society of Hospital Medicine*, 2, 422-432.
- Rivers, E., Nguyen, B., Havstad, S., Ressler, J., Muzzin, A., Knoblich, B. et al. (2001). Early goal-directed therapy in the treatment of severe sepsis and septic shock. *New England Journal of Medicine*, 345, 1368-77.

- Rothschild, J., Woolf, S., Finn, K., Friedberg, M., Lemay, C., Furbush, K., et al. (2008). A Controlled Trial of a Rapid Response System in an Academic Medical Center. *Joint Commission Journal of Quality and Patient Safety*, 34 (7), 417-425.
- Rubulotta, F., & Pinsky, M. (2008). Second International Conference on Rapid Response System and Medical Emergency Team. *Critical Care*, 10, 319.
- Schein, R., Hazday, N., Pena, M., Ruben, B., & Sprung, C. (1990). Clinical Antecedents to in-hospital cardiopulmonary arrest. *CHEST*, 98, 1388-1392.
- Schmid, A., Hoffman, L., Happ, M.B., Wolf, G., & DeVita, M. (2007). Failure to Rescue, A Literature Review. *The Journal of Nursing Administration*, 37, 188-198.
- Schmid-Mazzoccoli, A., Hoffman, L., Wolf, G., Happ, M., & DeVita, M. (2008). The use of medical emergency teams in medical and surgical patients: impact of patient, nurse and organisational characteristics. *Quality and Safety in Health Care*, 17, 377-381.
- Sebat, F., Musthafa, A., Johnson, D., Kramer, A., Shoffner, D., Eliason, M., et al. (2007). Effect of a rapid response system for patients in shock on time to treatment and mortality during 5 years. *Critical Care Medicine*, 35, 2568-2575.
- Silber, J., Williams, S., Krakauer, H., & Schwartz, S. (1992). Hospital and Patient Characteristics Associated with Death After Surgery. *Medical Care*, 30, 615-629.
- Silber, J., Rosenbaum, P., & Ross, R. (1995). Comparing the contributions of groups of predictors: Which outcomes vary with hospital rather than patient characteristics. *Journal of the American Statistical Association*, 90, 7-18.
- Smith, A.F., & Wood, J. (1998). Can some in-hospital cardio-respiratory arrests be prevented? A prospective survey. *Resuscitation*, 37(3), 133-7.

- Stevenson, V., Haas, C. & Wahl W. (2002). Intrahospital transport of the adult mechanically ventilated patient. *Respiratory Care Clinics of North America*, 8(1), 1-35.
- Subbe, C., Williams, E., Fligelstone, L., & Gemmell, L. (2005). Does earlier detection of critically ill patients on surgical wards lead to better outcomes? *Annals of The Royal College of Surgeons of England*, 87, 226-232.
- Szem, J., Hydo, L., Fischer, E., Kapur, S., Klemperer, J. & Barie, P. (1995). High-risk intrahospital transport of critically ill patients: Safety and outcome of the necessary “road trip”. *Critical Care Medicine*, 23(10), 1660-1666.
- Sundararajan, V., Henderson, T., Perry, C., Muggivan, A., Quan, H., & Ghali, W. (2004). New ICD-10 version of the Charlson Comorbidity Index predicted in-hospital mortality. *Journal of Clinical Epidemiology*, 57, 1288-1294.
- The Joint Commission. Accreditation Program: Hospital National Patient Safety Goals. (2008). The Joint Commission on Accreditation of Healthcare Organizations.
- Voigt, L., Pastores, S., Raouf, N., Thaler, H., & Halper, N. (2009). Intrahospital transport of critically ill patients: outcomes, timing and patterns. *Journal of Internal Care Medicine*, 24(2), 108-115.
- Warren, J., Fromm, R., Orr, R., Rotello, L., Horst, M., & American College of Critical Care Medicine. (2004). Guidelines for the inter- and intrahospital transport of critically ill patients. *Critical Care Medicine*, 32(1), 256-262.
- Waydas, C. (1999). Intrahospital transport of critically ill patients. *Critical Care*, 3, R83-R89.

Winters, B., Pham, J., Hunt, E., Guallar, E., Berenholtz, S., & Pronovost, P. (2007). Rapid Response systems: A systematic review. *Critical Care Medicine*, 35, 1238-1243.

Winters, B., Pham, J., & Pronovost, P. (2006). Rapid Response Teams - Walk Don't Run. *Journal of the American Medical Association*, 296, 1645-1647.