Evidence Report/Technology Assessment
Number 74

The Effect of Health Care Working Conditions on Patient Safety

Agency for Healthcare Research and Quality

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The Effect of Health Care Working Conditions on Patient Safety

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review prior to their release.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

We welcome written comments on this evidence report. They may be sent to: Director, Center for Practice and Technology Assessment, Agency for Healthcare Research and Quality, 6010 Executive Blvd., Suite 300, Rockville, MD 20852.

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The authors of this report are responsible for its content. Statements in the report should not be construed as endorsement by the Agency for Healthcare Research and Quality or the U.S. Department of Health and Human Services of a particular drug, device, test, treatment, or other clinical service.

Acknowledgments

Valuable assistance for this project was provided by several groups of individuals, including an expert panel, a technical advisory panel, and external peer reviewers. The names of these individuals are included in Appendix A, and the research team would like to acknowledge their helpful contributions to the project. We also acknowledge the efforts of the Evidence-based Practice Center support staff, specifically Patty Davies, MS, Maria Shaffer, Crystal Swails, and Susan Wingenfeld. Our Task Order Officer from the Agency for Healthcare Research and Quality, Ernestine Murray, RN, MAS, provided invaluable assistance. We also acknowledge the assistance of Eric Coleman, MD, University of Colorado, Denver, CO; Harvey J. Murff, MD, Harvard Medical School, Boston, MA; Dean Sittig, PhD, Kaiser Center for Health Research, Portland, OR; and Robert M. Wachter, MD, University of California, San Francisco, CA, for advice during the course of the project.

Structured Abstract

Objectives. The purpose of this report is to compile and summarize existing evidence on the aspects of the working environment that impact patient safety. Five categories of working conditions were evaluated: workforce staffing, workflow design, personal/social issues, physical environment, and organizational factors.

Search Strategy. Five bibliographic databases were searched; the databases were chosen to include citations from both the healthcare and non-healthcare literature. The databases included MEDLINE (with HealthSTAR), CINAHL, PsycINFO, EBSCO, and the Campbell Collaboration. Searches were conducted back to 1980 for MEDLINE and EBSCO, back to 1982 for CINAHL, and back to 1984 for PsycINFO. Additional studies were identified through hand searches of reference lists and selected tables of contents. Unpublished studies were identified through discussions with content experts.

Selection Criteria. The criterion for inclusion in the literature review was that the article addressed patient safety or human performance, together with predetermined definitions of working conditions. Studies with no original data were excluded unless they were systematic literature reviews. Selection criteria were tested through dual reviews by a second investigator.

Data Collection and Analysis. The articles included in the general literature review guided the definition of subcategories within the five main categories of working conditions. The quality of the evidence in individual studies was assessed through separate ratings of study design and execution. For each of the working-condition categories, six key questions were addressed to classify the nature of the evidence linking the working condition to aspects of patient safety.

Main Results. The strongest evidence linking working conditions to aspects of patient safety is in the areas of workforce staffing and workflow design. Specific working conditions in these two categories affect both rates of medical errors and the incidence of patient outcomes related to patient safety. The patient outcomes affected include hospital-acquired infections, decubitis ulcers, and patient falls. There is not consistent evidence that working conditions affect the rates of preventable deaths in hospitals.

Conclusions. The available evidence supports the recommendation that healthcare systems initiate demonstration projects and translational research to modify working conditions with the goal of improving patient safety. Specific areas in which such efforts are likely to be successful include: changes in nursing staffing, channeling high-risk technical procedures to high-volume physicians, avoidance of distractions in the healthcare workplace, and processes to improve information exchange between hospital and non-hospital settings. In addition, previous suggestive-but-inconclusive research indicates that limited investigations of workplace stress, lighting conditions, and organizational factors will clarify whether these additional working conditions affect patient safety.

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Number 74

The Effect of Health Care Working Conditions on Patient Safety

Summary

Overview

Do the working conditions of health care personnel contribute to the incidence of medical errors? This question is often raised during public discussion of ways to improve patient safety. How much do issues of nurse staffing and doctors' hours, for example, contribute to the estimated 44,000 to 98,000 deaths per year in hospitals due to medical errors?

The objective of this report is to identify and summarize evidence from the scientific literature on the effects of health care working conditions on patient safety. The report also identifies relevant information from industries outside of heath care.

Working conditions were classified into five categories: workforce staffing, workflow design, personal/social factors, physical environment, and organizational factors. The classification system for working conditions was derived from existing literature and advice from an expert panel. It is consistent with human factors research in multiple disciplines and industries such as aviation and nuclear power. Workforce staffing refers to job assignments and includes four principal aspects of job duties: the volume of work assigned to individuals, the professional skills required for particular job assignments, the duration of experience in a particular job category, and work schedules. Workflow design focuses on the job activities of health care workers, including interactions among workers and the nature and scope of the work as tasks are completed. Personal/social factors refer to individual and group factors such as stress, job satisfaction, and professionalism. Physical environment includes aspects of the health care workplace such as light, aesthetics, and sound. Organizational factors are structural and process aspects of the organization as a whole, such as use of teams, division of labor, and shared beliefs.

The researchers developed an analytic framework to define how working conditions are related to patient safety. Antecedent conditions, which are external factors such as personal characteristics of workers and fixed structural characteristics of the system (e.g., geographic location, regulations, and legislation), can affect the impact of working conditions on patient safety. Working conditions are viewed either as resources that improve work quality or as demands that impede work quality. Working conditions potentially affect patient safety, which leads to patient outcomes.

The researchers also developed a model of patient safety to help frame the key questions and provide a way to synthesize data reported in studies. The model is drawn from injury analysis and incorporates elements of both processes and outcomes. It is based on the relationships between medical errors (defined as the failure of a planned action to be completed as intended, or the use of a wrong plan) and adverse outcomes (injuries caused by health care rather than underlying disease).

Reporting the Evidence

The key questions derive directly from the analytic framework. Each key question applies to all five categories of working conditions; specific working conditions are inserted into the key questions for each of the five categories. The key questions permitted the research team to classify the entire body of evidence for each category and to derive a judgment about the strength of evidence regarding the contribution of the

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working condition categories to overall patient safety. The six key questions are:

1. Do working conditions affect patient outcomes that are related to patient safety?
2. Do working conditions affect the rate of medical errors?
3. Do working conditions affect the rate of recognition of medical errors after they occur?
4. Do working conditions affect the probability that adverse events will occur following detected or undetected medical errors?
5. Does the complexity of the plan of care influence whether working conditions affect patient outcomes that are related to patient safety?
6. Do working conditions affect measures of service quality in industries other than health care?

The populations of interest for this report include health care workers, patients, and workers in industries other than health care. The outcomes considered are defined in the analytic framework and model of patient safety and hence the key questions. They include patient outcomes, medical errors, and adverse events.

Methodology

To identify relevant literature the researchers searched five databases: MEDLINE® (with HealthSTAR), CINAHL®, PsycINFO, EBSCO, and the Campbell Collaboration. The Campbell Collaboration is an international effort modeled on the Cochrane Collaboration. The Campbell Collaboration prepares, maintains, and disseminates systematic reviews of the effectiveness of social and educational policies and practices. Its Social, Psychological, Educational and Criminological Trials Register (C2-SPECTR) is a registry of randomized and possibly randomized trials in education, social work and welfare, and criminal justice. The researchers searched MEDLINE (1980 to 2002) and CINAHL (1982 to 2002) to capture the health care literature, and they searched PsycINFO (1984 to 2002) and EBSCO (1980 to 2002) to capture literature outside of health care. The searches were limited to the years 1980 to 2002 because most contemporary quality management and accreditation systems have been implemented since 1980. Searches were performed separately for each of the five categories of working conditions (workforce staffing, workflow design, personal/social factors, physical environment, and organizational factors). Search strategies were developed by the lead investigator for each working condition category, using MeSH® terms where possible. Searches were limited to human studies and those in the English language or with English abstracts. The searches resulted in a total of 23,179 citations.

The lead investigator for each working condition category applied a set of inclusion/ exclusion criteria to the titles/abstracts in their area. To assess the interobserver reliability of this process, dual reviews were performed on random samples of citations. Full-text papers were retrieved for studies judged to be possibly relevant and assessed again for relevance using the same inclusion/exclusion criteria.

Studies were then abstracted using data-abstraction guidelines, and quality ratings were applied. The researchers rated design suitability and quality of study execution. They constructed evidence tables, and a second investigator reviewed the studies to verify the accuracy of the summary information and quality ratings.

Findings

After the investigators had reviewed all citations for possible relevance, over 1,000 papers were retrieved and read; of these, 912 papers were excluded from further review. Of the excluded papers, 730 were health care related and 182 focused on industries outside of health care. The bibliography includes the excluded studies.

A total of 115 studies were found to have evidence relevant for answering the key questions and were included in evidence tables. In some cases, additional studies were found to provide evidence that was indirectly related to key questions. The volume of available evidence varied considerably among the categories of working conditions, which reflects extensive variability in the amount of research conducted in these domains.

With the exception of Key Question 4 (regarding impact on the probability of adverse events), valid evidence was found for all key questions. The largest amount of available evidence applied to Key Question 1, and there was sufficient evidence to conclude that several different specific working conditions affect outcomes that are related to patient safety. There also was sufficient evidence to conclude that some working conditions affect rates of medical errors (Key Question 2).

The results of studies of factory and office workers are generally consistent with similar studies performed in health care settings (Key Question 6). These findings suggest that studies of working conditions in other industries are relevant to health care and can be used to expand the fund of knowledge about working conditions in health care.

The systematic literature review provided sufficient evidence to make specific recommendations about strategies for improving patient safety. These recommendations can be summarized as follows:

- Strategies to increase staffing levels of licensed and unlicensed nurses in both acute-care hospitals and nursing homes will likely lead to improved patient outcomes.
- Preventable complications are lower when complex technical procedures are performed by physicians who conduct them frequently (i.e., high-volume physicians).
- Duration of experience of the health professional is associated with better patient outcomes for some types of clinical care.

- Systems to reduce interruptions and distractions will likely reduce the incidence of medical errors.
- Systems to improve information exchange, transfer of responsibility, and continuity of care between hospital and nonhospital settings ("hand offs") decrease medication errors and, in some settings, hospital re-admissions.
- Levels of ambient noise in health care settings do not adversely affect patient safety.

Future Research

For several specific working conditions, there is evidence that the working condition affects patient safety, but the evidence comes from few studies and is insufficient to draw clear conclusions. Further research to clarify and confirm the findings from existing studies will permit judgments to be made about the importance of these working conditions. The areas in which such targeted research is indicated include workplace stress, workplace lighting conditions, and several aspects of organizational factors.

With the exception of selected work processes pertaining to workflow design, most of the evidence on the relationship of working conditions to patient safety is derived from non-experimental studies. Thus, there remain unanswered questions about the magnitude of improvement in patient safety that can be achieved by improving working conditions. There is a need for significant future research that evaluates how specific workplace interventions will affect patient outcomes. Such research could be conducted as clinical trials or as carefully designed demonstration projects and program evaluation studies.

Availability of the Full Report

The full evidence report from which this summary was derived was prepared for AHRQ by the Oregon Health and Science University Evidence-based Practice Center under contract number 290-97-0018. It is expected to be available in spring 2003. Printed copies may be obtained free of charge from the AHRQ Publications Clearinghouse by calling 800-358-9295. Requesters should ask for Evidence Report/Technology Assessment No. 74, *The Effect of Health Care Working Conditions on Patient Safety*. When available, Internet users will be able to access the report online through AHRQ's Web site at: www.ahrq.gov.

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Evidence Report

Chapter 1. Introduction

Patient Safety and Medical Errors

The healthcare delivery system includes a broad range of technical resources and personnel. Healthcare services expose patients to the risk of unintentional injuries that can range from trivial and nondisabling to severe permanent disability or death. Efforts to minimize these injuries have led to the patient safety movement, and the generally accepted definition of patient safety is the prevention and amelioration of adverse outcomes or injuries stemming from the processes of health care.[1]

In order for health care to be safe, efficacious, and of high quality, it is essential that there be optimal coordination of the structural and cultural elements of the system.[2] Because this requirement is not always met, medical errors occur, and patient safety is threatened. The sources of error are diverse, including failure of process safeguards, faults in equipment, or lack of teamwork. Patient safety is thereby dependent on the optimal interactions of the components of the healthcare system, with errors being minimized. A medical error is defined as the failure of a planned action to be completed as intended ("error of execution") or the use of a wrong plan to achieve an aim ("error of planning").[1] Because of the complexity of the healthcare system, errors may occur in hospitals, outpatient clinics, nursing homes, pharmacies, urgent care centers, and patients' homes.

Distinguishing between active and latent error provides insight into the need to understand a work process and its weaknesses.[3] Active errors occur at the level of the frontline operator, and their effects are felt almost immediately. Latent errors are removed from the direct control of the operator and include poor system design and poorly structured organizations. Latent errors pose the greatest threat to safety, because they often are unrecognized and have the capacity to result in multiple types of active errors. A focus on active errors lets the latent failures remain in the system, making the system even more prone to future failure. The key to reducing errors is to focus on improving the systems of delivery of care as well as the performance of individual workers.

Clinicians and managers accept that efforts should be made to reduce errors, but the best strategies for error reduction have not always been well understood. In recent years, systematic efforts to improve quality have become widespread,[4] and there has been progress in understanding how the processes and outcomes of care are related.[5, 6] The progress in quality improvement in health care has led to an environment of proactive approaches to recording information about the processes of clinical care that makes investigations of medical errors more feasible.

Contemporary research on patient safety has its origin in the examination of adverse outcomes of care. Adverse outcomes are defined as injuries caused by health care rather than by underlying disease. While not all adverse events are preventable, some are due to preventable errors. Adverse outcomes were first systematically measured in a study conducted by the California Medical Association in the 1970s.[7] The study found that significant adverse events occurred in 4.65 percent of hospitalizations. Two subsequent large-scale studies reported adverse event rates of 3.7 percent[8] and 2.9 percent.[9] By pooling the data from multiple studies, it has been estimated that significant adverse events occur in 3 to 4 percent of hospitalizations.[10] Patients undergoing surgical procedures account for two-thirds of all adverse events.[11] There has

been less examination of the incidence of adverse events among outpatients. One study reported the rate to be less than one per 10,000 clinic visits, but this is undoubtedly an underestimate.[12]

While the earlier studies focused on negligence as a cause of adverse events, other research examined errors due to faulty implementation of systems of clinical care. Optimal clinical systems feature safeguards to compensate for simple mistakes made by individual clinicians. In one study, failures at the system level were responsible for 75 percent of adverse drug events.[13] System improvements have also been shown to reduce error rates and improve the quality of health care. The Agency for Healthcare Research and Quality (AHRQ) recently published an evidence report on patient safety practices, defined as processes or structures whose application reduces the probability of adverse events resulting from exposure to the health care system. When applying this definition, the report focused on a broad range of specific health care practices, most of which are applicable only to the inpatient setting.[14]

Purpose and Scope of this Report

The purpose of the current report is to compile and summarize existing evidence on the aspects of the work environment that impact patient safety. While much of the relevant evidence comes from research conducted in healthcare settings, this report also has compiled evidence from the large body of human factors research conducted in the non-healthcare setting. This non-healthcare evidence provides insight into how work environment changes may improve patient safety.

Theoretical and empirical research from industries such as aviation and nuclear power provide a basis for a classification system of working conditions. This work allows us to organize the evidence derived from research conducted in healthcare and non-healthcare settings. The classification system used for this report is consistent with definitions used in the human factors research field.

We convened a panel of experts to define the working conditions addressed in this report. The panel identified five distinct categories of working conditions, as follows:

- Workforce staffing
- Workflow design
- Personal/social
- Physical environment
- Organizational factors

A common feature of these five categories is that the working conditions are potentially amenable to change. However, the resources needed to bring about change can vary greatly across the categories. For example, changing physical environment working conditions usually requires control over the mechanical and aesthetic aspects of healthcare facilities. Alternatively, changing staffing conditions requires access to financial resources and deployment of workers across organizational levels.

The audience for this report includes clinicians, health system managers, policy makers, and health services researchers. Individual clinicians can use the information in this report to improve their understanding about how features of their jobs affect their professional performance. This understanding can then be used to evaluate whether any changes in their own

job procedures are indicated. Health system managers can use the information to evaluate how changes in the organization of clinical delivery systems can achieve improvement in patient outcomes. Policy makers can use the information to guide decisions about resource commitments for system changes and research priorities. Health services researchers can use the information to identify gaps in knowledge that can guide new research initiatives.

Definitions of Working Conditions

Because the definitions of working conditions formed the basis for literature search strategies used in this project, a systematic process was used to solidify the definitions at the beginning of the project. A panel of experts on working conditions was identified and convened for a one-day meeting in November 2001 in Portland, Oregon. The members of the panel, listed in Appendix A, included healthcare researchers and human factors researchers in other fields such as aviation. The charge to the expert panel was to gain consensus on a classification system for working conditions that was broad enough to include all-important research relevant to patient safety. The panel was also asked to help with the conceptualization of the problem and definition of key questions to be addressed in the report. The panel was provided with background information on patient safety and a framework for understanding how patient safety is related to healthcare delivery.

The expert panel provided guidance on the categorization of working conditions that would permit sufficient coverage of all pertinent existing literature. Working definitions of the five categories then needed to be finalized before initiating the literature searches. These definitions were further refined during the search process and following review of all search results. Because the relevant literature needed to be assigned to single categories for reporting the evidence, the definitions were constrained so as to avoid overlap across categories. Specific factors (such as seasonal effects) that could reasonably be assigned to multiple categories were assigned to the category that was the closest fit. The final definitions of each category are summarized in the following sections.

Workforce Staffing

Workforce staffing refers to the job assignments of healthcare workers. It includes four principal aspects of job duties:

1. The volume of work assigned to individuals. This has been defined in different ways depending on the nature of the job assignment. For pharmacists it has been defined as the number of prescription orders filled per day. For nursing staff, it has been defined as the number of patients cared for during a work shift. For physicians, it has been defined as the number of a certain procedure (such as coronary arteriography or resection of a gastric carcinoma) performed per year. The most common hypothesis is that higher workload is associated with a larger rate of errors and/or adverse outcomes. However, most research on physician performance has been based on the hypothesis that higher workload is associated with a lower error rate, due to differences in the unit of measurement and nature of clinical tasks.

2. The professional skills required for particular job assignments. This has usually been defined as attainment of advanced academic degrees or specialty certifications. However, some research has examined the effects of focused training programs for existing staff members. The usual hypothesis has been that higher levels of prior training are associated with lower error

rates. Current concerns over the demographic trends toward a shrinking workforce for some professional areas (particularly nursing) has also led to research on the effects of shifting some job duties to less highly trained personnel (such as using unlicensed personnel for performance of nursing tasks and using pharmacy technicians to provide pharmacy services as allowed by state/federal law).

3. The duration of experience in a particular job category. Duration is usually measured as the number of years an individual has worked in a particular job category. Some studies of physicians in academic settings have used faculty rank as a measure of experience. The most common hypothesis is that longer experience is associated with lower error rates.

4. Effects of work schedules, including length of shift, days of the week worked, and temporal cycle effects (such as influence of time of week or season of year). A common hypothesis is that longer work shifts are associated with a greater incidence of errors.

Workflow Design

Workflow design focuses on the process of delivering health care. Healthcare facilities are complex collections of simpler units organized to support the workflow to deliver patient care.[15] Workflow design encompasses the interactions among workers and also between workers and the workplace. It also includes the nature and scope of the work as tasks are completed. In health care, as in other industries, hazards to workers and patients can be evaluated by examining specific work processes.[15] This allows for the analysis of risks in the system and the impact of those risks on the worker and patient. A useful framework for analyzing workflow design integrates approaches from several disciplines, including organizational psychology, industrial engineering, biomechanics and ergonomics.[16] For evaluating patient safety, workflow design includes task design and workplace design relevant to accomplishing the tasks. Task design includes such job characteristics as redundancy, complexity, distractions, and transfer of information and responsibility to others ("hand-offs"). Workplace design considers worker ergonomics for technology and equipment.

Personal/Social

This category of working conditions is concerned with the personal, professional, and social aspects of the healthcare work environment. The personal factors include stress, burnout, dissatisfaction, motivation, and control over work. Social factors include interrelationships among workers, such as collectivism, role ambiguity, discord, and support. Professionalism includes the values that are cultivated within professional disciplines such as nursing or clinical pharmacy.

Physical Environment

Physical environment working conditions include direct physical characteristics such as light, aesthetics, noise, air quality, toxic exposures, temperature, and humidity. This category also includes basic workplace design features, such as obstacles, physical layout, and distance from nursing stations.

Organizational Factors

Organizational factors are structural and process aspects of the organization as a whole. For example, work structures such as the use of teams and the division of labor are organizational factors with potential influences on patient safety. Other organization-level factors include size, funding mechanisms (e.g., profit, not-for-profit), hospital type (e.g., teaching, private), and culture. Some aspects of the organization, such as size and funding base, are difficult to change. Other aspects, such as the use of team structures and culture, are more amenable to change. Organizational culture is what employees throughout an organization perceive and how this perception creates a pattern of beliefs, values, and expectations. Specific characteristics of organizational culture include managerial style, evaluation and reward systems, economic effects, hierarchy, accountability, decision latitude, and employee feedback.

Analytic Framework

Our goals in constructing an analytic framework were to elucidate the major concepts pertinent to the work environment and the theoretical linkages between concepts. Our analytic framework is based on a model that characterizes working conditions as factors that can either improve work quality (referred to as resources) or impede work quality (referred to as demands).[17-19] The quality of work in turn affects patient safety and patient outcomes.

Antecedent variables can also affect human performance. Antecedent factors can potentially moderate the effect of working conditions on patient safety, which in turn influences patient outcomes. These variables include personal characteristics of workers and structural characteristics of the system that cannot be changed. They include worker age, gender, personal health, job commitment, geographic location, and regulations and legislation that affect the healthcare system (Figure 1). Some research has been conducted on the influence of these factors upon the job performance of health professionals. For example, professional impairment due to chemical dependency, psychiatric impairments, or other medical conditions upon job performance has been an important area of inquiry.[20-23] Since these antecedent variables were not classified as working conditions, research in these domains was not reviewed for this report.

In order to synthesize data reported in studies, it also is necessary to have a model of patient safety. We have extended a model originally developed by the federal Quality Interagency Coordination Task Force.[24] Our model (Figure 2) uses Haddon's system of analyzing injuries, with pre-injury, injury, and post-injury phases.[25] It also incorporates Reason's model of accidents based on system processes and human errors.[3] Because it includes elements of both processes and outcomes, this model provides a framework for classifying and tabulating the types of data reported in studies of working conditions in health care.

This report does not consider evidence about other effects of working conditions on health professionals, such as injuries, turnover, or absenteeism (though these are obviously important in their own right), except where they are included with more direct measures of patient safety or harm. Similarly, this report does not consider evidence about other effects of working conditions on clinical practices, such as measures of the relative desirability or quality of care, except where the focus is on errors or patient safety. Finally, the relationship between clinical practices and patient outcomes is often neither direct nor certain. Even when clinical practices are ideal, patients may or may not improve, and may even deteriorate (Figure 2). Likewise, when errors do occur, patient outcomes may or may not reflect this (a "close call" is an error that

does not lead directly to an adverse event). Further complicating this picture is the substantial disagreement that exists in expert judgments about whether errors have occurred and whether, when they have occurred, adverse outcomes have been the result.[26, 27]

Key Questions

Our set of key questions was derived directly from the analytic framework. The core group of key questions applies to all five categories of working conditions. The key questions permitted the research team to classify the entire body of evidence for each category and to derive a judgment about the strength of evidence regarding the contribution of the working condition categories to overall patient safety. The six key questions are:

1. *Do working conditions affect patient outcomes that are related to patient safety?*
2. *Do working conditions affect the rate of medical errors?*
3. *Do working conditions affect the rate of recognition of medical errors after they occur?*
4. *Do working conditions affect the probability that adverse events will occur following detected or undetected medical errors?*
5. *Does the complexity of the plan of care influence whether working conditions affect patient outcomes that are related to patient safety?*
6. *Do working conditions affect measures of service quality in industries other than health care?*

The Evidence-based Approach

An evidence report focuses attention on the strength and limits of evidence from published studies about the delivery of health care. The development of an evidence report begins with a careful formulation of the problem. In this phase, a preliminary review of the literature and input from experts, stakeholders, and patients may be used to identify the patient populations, interventions, health outcomes, and harms. An evidence report also emphasizes the quality of the evidence, giving more weight to studies that meet high methodological standards that reduce the likelihood of biased results. An evidence report pays particular attention to the generalizability of studies performed in controlled or academic settings. Studies that reflect actual clinical effectiveness in unselected patients and community practice settings are highlighted.

In the context of developing clinical guidelines, evidence reports are useful because they define the limits of the evidence, clarifying when the assertions about the value of the intervention are based on strong evidence from clinical studies. The quality of the evidence on effectiveness is a key component, but not the only component, in making decisions about clinical policies. Additional criteria include acceptability to physicians or patients, the potential for unrecognized harms, and cost-effectiveness.

Previous Systematic Reviews

In conducting the literature reviews that formed the basis of this report, previously performed systematic reviews were identified and are summarized where pertinent in the following

chapters. When possible, we avoided duplicating work reviewed in other good-quality evidence reports and systematic reviews. Of particular note is AHRQ Evidence Report/Technology Assessment Number 43 (*Making Health Care Safer: A Critical Analysis of Patient Safety Practices*), published in 2001.[14] That report summarizes evidence on a variety of patient safety practices and includes information on several types of workflow design working conditions and also on some other categories of working conditions. Another notable systematic review examined the relation of hospital volume to quality.[28]

Chapter 2. Methodology

Literature Search and Selection Methods

Sources

To identify relevant literature we searched five databases: MEDLINE (with HealthSTAR), CINAHL, PsycINFO, EBSCO, and the Campbell Collaboration. PsycINFO indexes dissertations as well as published articles in a wide range of journals not included in MEDLINE. Within EBSCO we searched Health Source: Nursing/Academic Edition, Academic Search Elite, Business Source Premier, and MasterFILE Premier. The Campbell Collaboration is an international effort modeled on the Cochrane Collaboration whose mission is to prepare, maintain, and disseminate systematic reviews of the effectiveness of social and educational policies and practices. Its Social, Psychological, Educational and Criminological Trials Register (C2-SPECTR, http://128.91.198.137/) is a registry of studies in education, social work and welfare, and criminal justice.[29] C2-SPECTR contains over 10,000 reports. It was constructed by searching three bibliographic databases that included Educational Research Information Clearinghouse (ERIC), Sociological Abstracts, and Criminal Justice Abstracts as well as hand searching 48 journals in sociology, psychology, education, criminology and other fields and other specialized reference lists, bibliographies, collections of individuals, and other sources. Only randomized and possibly randomized trials are included in the C2-SPECTR database.

We searched MEDLINE (back to 1980) and CINAHL (back to 1982) to capture the healthcare literature, and we searched PsycINFO (back to 1984) and EBSCO (back to 1980) to capture all available industry literature. We searched MEDLINE, CINAHL, and PsycINFO again during the course of the project, with the final search in August 2002. Following the searches of literature databases, additional published studies were identified through hand searches of reference lists and selected tables of contents. Unpublished studies and government reports were identified through discussions with content experts and electronic mail lists.

Search Methods

Each search was organized by a lead investigator and was based on the set of six key questions; each of the five working conditions (workforce staffing, workflow design, personal/social, physical environment, and organizational factors) was searched separately. We defined the timeframe of the searches to be 1980 to the present, because most current quality management and accreditation systems have been implemented since 1980. Some of the databases did not go back as far as 1980, so these were searched in their entirety. Searches were limited to human studies and the English language but included foreign articles with an English abstract. Additionally, MEDLINE and CINAHL searches included a set of search terms that addressed medical errors, safety, and quality, and were constrained to articles pertaining to health care. Each search strategy was complemented by terms specific for one of the working condition categories. PsycINFO searches were not constrained to a specific industry and addressed performance measures and errors. As mentioned above, each search strategy was complemented by terms specific for one of the working condition categories. The search strategy for EBSCO was also not constrained to a specific industry. The search terms were working conditions and

productivity, human performance, and employee productivity and performance. The search strings for the other databases (MEDLINE, CINAHL, PsycINFO, and the Campbell Collaboration) are provided in Appendix B. We entered retrieved titles/abstracts into an EndNote® database, except for the EBSCO and Campbell Collaboration databases, where only included studies were entered.

Selection Processes

The searches resulted in a total of 23,179 citations. The lead investigator for each of the working condition categories reviewed the titles/abstracts for the citations that fell into their working condition category. Table 1 lists the eligibility criteria that were applied during the title/abstract review. For the non-healthcare industries, studies which met the criteria in Table 1 were considered for inclusion if they reported any measure of work results or productivity.

Table 1. Inclusion/exclusion criteria for judging titles/abstracts and full text papers

Code #	Justification for codes
	Inclusions
1	IN: For this category of working conditions
2	IN: For *another* category of working conditions
	Indicate which one:
	A. Physical Environment
	B. Workflow Design
	C. Workforce Staffing
	D. Organizational Factors
	E. Personal/Social
3	IN: Good review or background article
	Exclusions
4	OUT: Does not address any key question
5	OUT: Does not report original data
6	OUT: Wrong population (animal study, etc.)
7	OUT: <specific to topic> Write justification below

Due to budgetary constraints, citations that required inter-library loans or foreign language translation were assessed again by each lead investigator to determine if they were key citations to obtain. The full texts of citations that met inclusion criteria from the title/abstract review were then obtained and assessed again for inclusion/exclusion using the same criteria (Table 1). The search and selection of citations is depicted in Appendix C. The EBSCO and Campbell Collaboration databases were not searched independently for each of the five working condition topics and are indicated as such in Appendix C.

Prior to the review of citations for inclusion, we conducted a process to ensure consistency in application of the review criteria. A dual review by the lead investigator for each category paired randomly with one of the other investigators was conducted on a random sample of the citations for each of the topics. Kappa values were calculated to assess inter-rater reliability.[30] The kappa values ranged from 0.10 to 0.56. The investigators met to review the disagreements and the inclusion/exclusion criteria. Consensus was achieved on the points that studies of human performance, staff turnover rates, and quality be included for the appropriate working condition so long as there were original data. Studies focusing on patient satisfaction and communication (except for technology) were excluded, in that they did not address any key question. Studies of providers' perceptions of health care were included.

A second dual review was initiated on a separate random sample to reassess inter-rater reliability. This review was conducted after the lead investigators had completed their reviews of approximately half of the search result sets. The kappa values were similar among four of the topic areas and ranged from 0.41 to 0.48. Based on this outcome, a single review of the titles/abstracts by lead investigator was deemed acceptable for these four categories.

The kappa value for the second dual review of one topic (organizational factors) was lower at 0.14. The source of disagreement between the two reviewers for this working condition category was related to the rates of studies judged relevant. The lead investigator rated 5 percent of the studies relevant, while the second reviewer rated 15 percent as relevant. For the other four working condition categories, the rates of relevance judgments ranged from 11 percent to 20 percent for all reviewers. A third investigator then reviewed a random sample of 200 of the citations in this category. The three investigators then met to review and revise the definition of organizational culture. Disagreements among the three investigators were found to be due to differences in how they defined the scope of organizational culture. The investigators gained consensus that the definition should be broadened (as reflected in the definition included in Chapter 1). The lead investigator then re-reviewed the entire set of citations.

Data Abstraction and Synthesis

Data Abstraction

All studies rated as relevant on the basis of review of titles and abstracts were retrieved, photocopied, and reviewed by the lead investigator for each working condition category. Studies judged to have evidence about a key question were then abstracted, with the details of methods and results recorded on data abstraction tables. The ratings of quality of study design and execution were assigned at this time (see further details in next section). To provide

guidelines for extraction of information into the data abstraction tables, the investigative team developed data abstraction guidelines (Appendix D).

Assessment of Study Quality

Our system for rating the quality of individual studies was based on previously published methods. Several approaches to evaluating quality were examined. We reviewed concepts from the U.S. Preventive Services Task Force, the *Guide to Community Preventive Services*, the Oxford Centre for Evidence-based Medicine, and AHRQ Evidence Report/Technology Assessment Number 47 *Systems to Rate the Strength of Scientific Evidence*.[31-34]

The approach that was best suited to the types of studies included in this report is based on the system used by the Task Force on Community Preventive Services.[32] This approach differs from that used in a previous evidence report on patient safety practices.[14] Each study was assessed for quality using two ratings. The first, suitability of study design, was a three-tier approach (greatest, moderate, and least) relating the strength of the study design to threats of internal validity. We developed a modified version of design suitability for our topic. We rated studies greatest, moderate, or least based on comparison group status and measures of other factors affecting outcomes (Table 2). The second measure of quality was the quality of study execution. Here, six areas of threats to validity have been described,[32] with the ratings of good, fair, or limited corresponding to 0-1, 2-4, or 5 or more limitations. We used a similar approach and rated study execution as good, fair, or poor based on internal and external validity. Internal validity was assessed by considering such factors as comparability of groups, differential loss to followup, measurement/instrumentation issues, maturation/pre-testing effects, and whether there was a clear description of interventions. External validity was assessed by considering such factors as a sensitized or pre-tested population, specialized/atypical population, selection biases (non-random subject selection), reactive effects of experimental settings, and multiple interventions.

Table 2. Design suitability

Greatest	Concurrent comparison groups and sufficient measures for other factors affecting outcomes
Moderate	Non-concurrent comparison groups or insufficient measures for other factors affecting outcomes
Least	Non-concurrent comparison or no comparison groups and insufficient measures for other factors affecting outcomes

The overall strength of the evidence per topic area was assessed based on the criteria outlined by the Task Force on Community Preventive Services.[32] The quality and quantity of the studies and size and consistency of the results were used to grade the overall strength of the

evidence. Where evidence was available, the body of evidence for a topic area was rated as strong, sufficient, or insufficient according to the parameters outlined in Table 3.

Table 3. Assessment of strength of evidence

Strong	At least two studies having greatest design suitability, good execution, and consistent results; or at least five studies having greatest design suitability, good or fair execution, and consistent results
Sufficient	At least one study with greatest design suitability and good execution; or at least three studies having moderate or better design suitability, fair or better execution, and consistent results
Insufficient	Too few studies to meet definition of sufficient evidence; or inconsistent results among multiple studies having some design or execution flaws

Methodologic Limitations

In this report we have adapted the methods of the systematic review[35] to collect, evaluate, and synthesize the best available evidence that addresses the key questions. However, these methods were not developed for the domain of inquiry in which we are applying them, and this has implications for the conclusions that can be reached and the degree of certainty with which they can be stated. The methods and assumptions of the systematic review of health interventions, as practiced by organizations such as the AHRQ Evidence-based Practice Centers and the Cochrane Collaboration[36] are not entirely applicable to a broad and diverse domain of inquiry such as that addressed in this report. Differences include those relating to a) underlying research traditions and assumptions; b) the search for relevant literature; c) selection of evidence for inclusion; d) appraisal of the relative validity and generalizability of studies; and e) combination or synthesis of evidence.

For healthcare interventions, the research tradition and assumptions of clinical epidemiology serve as the foundation both for original studies and syntheses of evidence. The underlying conditions, the interventions used to identify or treat them, and the outcomes of interest are generally well defined, with established and agreed upon means of identifying patients for inclusion and measuring outcomes of interest. The research designs used to investigate these interventions and conditions are well established and agreed upon, with defined limitations and biases and a familiar hierarchy of levels of evidence.[33] As a result, studies of a particular intervention for a particular condition can usually be compared, results of selected studies can be combined, and the result often be expressed in terms of a single numeric estimate of effect, with an appropriate and precise estimate of precision.

In contrast, the evidence for this report is drawn from both healthcare and non-healthcare fields and includes diverse domains of inquiry, with different research traditions and assumptions, including cognitive science, sociology, industrial and human factors engineering, and others. In many cases there are no uniform definitions of underlying conditions, interventions, or outcome states, and no single commonly accepted means of identifying or

measuring them. Furthermore, these domains of inquiry do not share a common, agreed upon hierarchical framework of research designs as in clinical epidemiology. As a result, it is often difficult to compare the results of studies, and it may be wholly inappropriate to attempt to combine them.

Controversy continues about whether research from the paradigm of clinical epidemiology should be the sole basis for recommendations for action, in particular regarding behavioral, organizational, or information interventions.[37-41] In view of this ongoing controversy, and the limitations of the application of the systematic review methods to the evidence examined herein, we have taken a hybrid approach, by summarizing evidence (where similarity of definitions and methods permits this) and separately describing individual studies (where summarization is not possible).

Synthesis of Evidence

The lead investigator for each category of working condition reviewed all studies included in the data abstraction tables and selected studies to be included in evidence tables. When multiple studies on a similar topic were available, studies that had the lowest design and execution ratings were not included in evidence tables. All studies included in evidence tables were reviewed by a second investigator to verify the accuracy of the summary information and quality ratings in the evidence tables. All evidence tables were then compiled by the principal investigator, and some studies were moved among tables if their results fit better with a different group of studies.

A technical advisory panel was identified, based on nominations from members of the expert panel. The technical advisory panel included six members with diverse backgrounds and broad knowledge of the field of patient safety (Appendix A). The final set of evidence tables and a draft of the narrative of the results chapter was submitted to the technical advisory panel for review. The panel then discussed the tables by a telephone conference call. The purpose of this review was to identify gaps in coverage of evidence from the entire domain of working conditions and to initiate supplementary literature searches based on the identified gaps.

Chapter 3. Results

Evidence on the Effects of Working Conditions

A total of 115 studies were found to have evidence relevant for answering the key questions and were included in evidence tables. In some cases, additional studies were found to provide evidence that was indirectly related to key questions. These studies are referred to and cited in the text but not included in evidence tables. The volume of available evidence also varied considerably among the categories of working conditions, which reflects extensive variability in the amount of research conducted in these domains. Three studies that provided evidence on more than one category of working conditions were included in more than one evidence table.[42-44]

Over 1,000 papers were retrieved and read, and of these, 912 papers were excluded. Of the excluded papers, 730 were healthcare related and 182 focused on industries outside of health care. The bibliography includes the excluded studies.

Evidence about the effects of working conditions on patient safety was derived from research conducted in both healthcare and non-healthcare settings. Generally, evidence from non-healthcare sources was consistent with that from health care, and we found no examples of significantly divergent findings between the two sources. Trends found in other industries tended to be replicated when evaluated in healthcare settings. For example, studies of ambient noise conducted in factory settings had results very similar to subsequent studies of noise exposure conducted among dispensing pharmacists. Nevertheless, much of human factors research conducted outside of health care has not been replicated or successfully adapted to the healthcare environment. For example, although there is an extensive body of research on crew resource management for aviation, this approach has had only limited success when applied to medical settings.[45]

Evidence applicable to the key questions is summarized in the following sections. The sufficiency of evidence to answer the key questions was greatest for the categories of workforce staffing and workflow design and least for the personal/social category. For some sub-categories of workforce staffing and physical environment, evidence from non-healthcare settings contributed substantially to answering key questions. However, most of the evidence judged sufficient for answering key questions came from research in health care.

Workforce Staffing

The literature searches on workforce staffing yielded the largest number of citations of all the working condition categories (Appendix C). More than 80 percent of the identified citations and retrieved documents were obtained through searches of MEDLINE. Most studies in this domain have been observational, and few clinical trials were identified. However, because similar approaches have been used in multiple studies, it is possible to assess consistency of findings across multiple international sites.

Research on workforce staffing in health care has been conducted for more than 25 years, and the investigations have addressed questions about workload issues, scheduling and coverage, and professional qualifications. Nearly all of the research has focused on nursing and physician staff. Thus, few conclusions can be drawn about staffing and scheduling for other health

professionals. Likewise, there has been relatively little research on workforce staffing outside of health care.

Much of the research about workforce staffing has been based on data from administrative data sets. These data sets have been derived from single hospitals, groups of hospitals, statewide sources (particularly New York, Maryland, Pennsylvania, and California), or national samples. The majority of studies has examined inpatient clinical care and has used adverse events as the outcome measure. Most of the adverse outcomes examined in these studies have clinical risk factors that affect their incidence, and nearly all the studies providing useful evidence have included methods of casemix adjustment. However, the casemix measures have varied considerably. Some studies include patients having only a single principal diagnosis, without additional severity measures for that chosen disease. Another common approach has been to use ICD-9 codes from discharge summaries to calculate diagnosis-based casemix measures. A common feature of these approaches is that the data source is clinical information drawn from administrative sources.

The available evidence on workforce staffing falls into three major categories: workload, professional qualifications, and work schedules. The concept of workload refers to the amount of direct patient contact a healthcare worker experiences over a defined period of time. Studies of workload have been conducted examining both nursing staff and physicians. However, the reported relationship between workload level and patient safety has been based on different conceptualizations for these two professional groups. For both licensed and unlicensed nurses, workload has been defined as the number of patients for which an individual is responsible to provide care during a work shift. Higher workload (i.e., a lower nurse to patient ratio) has been hypothesized to be associated with poor quality of care, because of time pressures that affect the ability to follow ideal clinical practices. For physicians, workload has been defined as the number of cases of a technical procedure performed by the physician over a certain time period. Higher workload has been hypothesized to be associated with better quality of care, because it leads to greater experience (and increased skill) in performing complex technical procedures. This difference is not surprising, in that the unit of measurement differs between the two groups. Nursing workload is typically measured by the number of patients cared for during an 8-hour shift, while physician workload is typically measured by the number of technical procedures performed per year.

Nurse Staffing

The evidence on the relationship between nurse staffing levels and measures of patient safety is provided by 26 studies summarized in Evidence Table 1.[42, 43, 46-69] Twenty-two of these studies have been published since 1996, and 21 were cross-sectional studies examining the relationship between measures of nurse staffing levels and adverse occurrences. Most commonly, these studies have examined in-hospital deaths and non-fatal adverse outcomes in the hospitalized setting, including various types of nosocomial infections, decubitus ulcers, and falls. In some studies, process errors have been measured, including medication errors. One additional study[70] was included in this table because it was based on a similar hypothesis (that higher workload leads to a greater number of errors). This study examined physician workload in an experimental setting, and its outcome measure was charting errors.

An important methodologic issue in this set of studies is the unit of analysis. All of the studies examining nursing workload used nurse-to-patient ratio as the method to estimate

workload. None of the studies examined individual nurses, so they all estimated workload by compiling staffing and patient occupancy data. For some studies, this was compiled by individual nursing units, while others aggregated these data for entire hospitals. One study[63] aggregated these data across groups of hospitals. A particular problem of hospital-level aggregation is that divergent nursing units are combined, including pediatric units, adult units, and intensive care units. Furthermore, these studies often have estimated hospital staffing levels by using payroll data reported to governmental agencies. This source of staffing data has been found to be consistently inaccurate, although not systematically biased.[68, 71]

The studies that aggregated data at the unit level were judged to have better quality than studies that aggregated data at the hospital level, due to the elimination of data pooling across individual units. Studies comparing similar units (such as studies of only intensive care units) were also judged to have higher quality. In one study that aggregated data at the unit level,[49] intensive care units were found to have consistently higher rates of all adverse events, regardless of staffing levels.

The measures of outcome in studies of nurse staffing are recorded at the patient level, by recording incidence of such adverse events as decubitus ulcers. From the patient's perspective, nursing workload can be characterized as the amount of staff time devoted to that particular patient. With higher nursing workload, a lower amount of time is available for any single patient. Thus, nursing workload has typically been reported using such measures as nursing hours per patient per day. A lower value of this ratio denotes a higher level of nursing workload for an individual staff member. The term "staffing" also has been used to denote this ratio, and higher levels of staffing connote higher nurse-to-patient ratios.

Non-fatal adverse events such as decubitus ulcers and patient falls have a plausible direct relationship to the availability of nursing staff. A consistent finding across most of the studies summarized in Evidence Table 1 is that lower nurse-to-patient staffing ratios were associated with higher rates of non-fatal adverse events. This result was found in studies that aggregated data at both the nursing unit and hospital level. While most of these studies used data from acute care hospitals, three[48, 67, 68] used data from statewide or multi-state samples of nursing homes. The findings from the nursing home studies are similar to those for acute care hospitals, with higher staffing being associated with lower adverse event rates. All three studies of nursing homes examined staffing ratios for both licensed nurses (registered nurses, licensed practical nurses, and licensed vocational nurses) and unlicensed nurses (nursing aides). Lower staffing ratios for both categories of staff were associated with higher adverse event rates.

Patient mortality conceptually is an imperfect measure of problems attributable to nurse staffing. While some patients die as a result of injuries related to health care, others die as a result of overwhelming disease. All of the studies evaluated for this report that used patient mortality as an outcome measure lacked methods for attributing the cause of death to preventable or non-preventable causes. Thus, it is not surprising that there was not agreement among the studies on whether lower nurse-to-patient ratios are associated with higher patient mortality (measured as either in-hospital mortality or death within 30 days of admission). The strongest evidence supporting such a mortality relationship examined patients with AIDS.[42] This study was conducted in 20 hospitals, aggregated data at the nursing unit level, and had good casemix controls. However, there have not been studies demonstrating a relationship between nurse staffing levels and patient mortality for other diagnoses. Among studies that did not select patients by diagnosis, a study examining a single intensive care unit[55] and two nationwide studies that aggregated data at the hospital level[43, 66] also found that lower nurse-to-patient ratios were

associated with higher patient mortality. Other studies examining multiple intensive care units[46, 50] and hospital-level staffing ratios[52, 63] did not find such a relationship.

The most common approach to examining staffing levels has been to record licensed nurse staffing and unlicensed nurse staffing as separate variables. In an attempt to provide insight into how overall staffing affects patient safety, some studies using data from acute care hospitals have examined ratios of registered nurses (RNs) to non-licensed nursing personnel. The best evidence that this ratio is important comes from a study that aggregated data at the unit level and had good casemix controls. That study found that a higher ratio of RNs to unlicensed nurses was associated with lower rates of both medication errors and decubiti.[49] Another study that aggregated data at the hospital level found that higher ratios of RNs to unlicensed nurses were associated with lower mortality rates.[64] A study that did not include casemix adjustment found no association between RN to unlicensed nurse ratio and non-fatal complications.[61] Another study that found a higher RN to unlicensed nurse ratio to be associated with higher medication error rates probably reported a spurious finding, because it compared intensive care units (ICUs) to general nursing units.[56] Blegen[72] also conducted a study that did not focus on nurse staffing levels but examined whether nursing units having higher proportions of registered nurses with baccalaureate degrees experienced lower complication rates for inpatients, but that association was not found. That study did find that units having lower complication rates tended to be staffed by nurses with a greater number of years of nursing experience.

The cumulative evidence on nursing workload is sufficient to provide answers to three of the key questions, as follows:

1. *Does nursing workload affect patient outcomes that are related to patient safety?* There is sufficient evidence to conclude that higher nursing workload is associated with higher rates of non-fatal adverse outcomes in both inpatient and nursing home settings. Increased staffing levels of either licensed nurses or unlicensed nurses was associated with lower rates of non-fatal adverse outcomes. The evidence is not consistent in demonstrating that higher nursing workload is associated with higher rates of patient mortality.
2. *Does nursing workload affect the rate of medical errors?* There is sufficient evidence to conclude that higher nursing workload is associated with higher incidence of medication errors.
3. *Does nursing workload affect the rate of recognition of medical errors after they occur?* There is insufficient evidence to answer this key question.
4. *Does nursing workload affect the probability that adverse events will occur following detected or undetected medical errors?* There is insufficient evidence to answer this key question.
5. *Does the complexity of the plan of care affect whether nursing workload affects patient outcomes that are related to patient safety?* There is sufficient evidence to conclude that the magnitude of the effect of nursing workload on patient outcomes differs between ICU and non-ICU settings.
6. *Do nursing working conditions affect measures of service quality in industries other than health care?* No studies in other industries were identified that examined measures of workload comparable to nurse/patient ratios, so research in non-healthcare settings was not found to be relevant to this category.

Physician Workload

Studies of physician workload have focused on a different hypothesis than that used in studies of nursing workload. The studies of physicians have mostly examined physicians who perform technical procedures, such as surgeons and cardiologists. The conceptual model of these studies is that repeated practice is necessary to maintain high-level technical skills. This leads to the hypothesis that physicians who perform fewer procedures over a defined time period will experience a higher rate of adverse events. In contrast to the research on nurses, the research on physician volume is not based on the premise that higher volume hinders availability to meet patient needs. Physicians have been classified as high volume on the basis of caring for as few as 3 patients per year with a particular diagnosis,[73] and physicians considered to be high volume operators often perform fewer than 100 procedures per year.

Many studies have used the hospital as the unit of aggregation and tested the hypothesis that hospitals with higher case volumes experienced lower complication rates. Such studies often have no data about individual physicians, so there are no data about working conditions as applied to individual physicians. Rather, they address the issue of whether certain procedures should be centralized in high-volume hospitals. A recent systematic review found substantial evidence that hospitals with higher case volumes experience lower complication rates.[28] That review also compiled evidence from studies that aggregated data on case volume to the level of the individual physician and concluded that physicians performing high rates of technical procedures experience lower rates of adverse outcomes. However, some studies that controlled for both institutional and physician volume failed to find that physician volume had a significant effect, suggesting that improved results may be due to institutional rather than physician-specific factors.[74,75] Additional evidence that institutional factors have a major effect on adverse event rates comes from a national prospective study of outcomes of surgical procedures conducted in Department of Veterans Affairs hospitals.[76] In that study, there was no relationship between volume of surgical cases and 30-day mortality rates. Institutional factors also may be responsible for the finding that case fatality rates decreased over time among cardiac surgery patients, independent of surgeon volume.[77]

Most studies of physician volume have selected cases based on the criterion that a particular procedure was performed. Relatively few studies have examined case volumes based on diagnoses rather than procedures. Studies based on cases defined by receiving a particular invasive technical procedure are inherently subject to the bias that the decision to perform a procedure is physician-dependent and may be influenced by past experience. Studies based on patients who have a particular condition (such as blunt trauma), rather than having received a particular procedure, permit examination of case volume independent of decisions about procedures. A recent systematic review[78] evaluated published studies examining the effects of institutional and physician volume on the outcomes of care for patients with cancer. That review found that there have been relatively few studies of patients with nonsurgical cancers and that the data from those studies are not sufficient to draw conclusions about individual physicians.

We found four studies that reported data about physician volume for patients identified by a particular diagnosis rather than performance of a procedure. These studies are summarized in Evidence Table 2.[44,73,79,80] We also included one additional study[81] that enrolled patients identified on the basis of having undergone coronary angioplasty. This study was included because it had complete data about all procedures performed at the five participating centers and included detailed and angiography data that permitted correcting for the severity of coronary

artery disease. Three of the five studies found that higher physician volume was associated with lower patient mortality rates, and these studies had higher methodologic ratings than the two studies with negative findings. One study[44] also examined the relationship between outcomes and physician case volume in relation to other characteristics of individual physicians. Older physicians experienced higher mortality rates, but other physician factors (faculty status and location of prior training) were not associated with mortality rates.

The cumulative evidence on physician workload is sufficient to provide answers to two of the key questions, as follows:

1. *Does physician workload affect patient outcomes that are related to patient safety?* There is sufficient evidence to conclude that higher physician workload is associated with lower in-hospital mortality rates. This finding has been observed both in studies of patients undergoing specific technical procedures and in studies of patients hospitalized for medical conditions that may or may not require performance of procedures.
2. *Does physician workload affect the rate of medical errors?* There is insufficient evidence to answer this key question.
3. *Does physician workload affect the rate of recognition of medical errors after they occur?* There is insufficient evidence to answer this key question.
4. *Does physician workload affect the probability that adverse events will occur following detected or undetected medical errors?* There is insufficient evidence to answer this key question.
5. *Does the complexity of the plan of care affect whether physician workload affects patient outcomes that are related to patient safety?* The identified studies have been limited to patients hospitalized with serious diseases, and there is little variation in complexity of care. There is insufficient evidence to conclude that complexity influences the rates of adverse events.
6. *Do physician working conditions affect measures of service quality in industries other than health care?* No studies in other industries were identified that examined measures of workload comparable to those used to evaluate physician performance, so research in non-healthcare settings was not found to be relevant to this category.

Professional Qualifications

Professional qualifications as a working condition affecting patient safety have been examined among both physicians and nurses. Many of the studies of physicians have compared fully trained physicians to trainees or less experienced trainees to more experienced trainees. We did not review these studies because it is widely accepted that medical school and residency training programs improve physician skills.

Studies conducted in pharmacies have found that pharmacists and pharmacy technicians have similar performance in the rates of medication errors. A single randomized trial compared pharmacists to pharmacy technicians as dispensers of prescriptions for ambulatory patients.[82] That study found that there was no significant difference in medication dispensing errors between the two worker groups. A non-experimental study comparing pharmacists to specially trained pharmacy technicians in the accuracy for identifying unit dose errors also found similar error rates between the two groups.[83]

For fully trained physicians, specialty certification has been examined in multiple studies. These studies have been based on the hypothesis that certain specialists provide better medical care than similarly trained physicians without specialty certification. The studies have measured both errors (such as inadequate tumor resection) and adverse events as outcomes. These studies are summarized in Evidence Table 3.[84-88] Four of the five studies examined surgical results and are consistent with the conclusion that physicians who have had more prior training on certain surgical procedures have better results when performing the procedure. The other study[88] found that patients with acute myocardial infarction had lower in-hospital mortality when cared for by a cardiologist.

The cumulative evidence on physician specialty is sufficient to provide answers to one of the key questions, as follows:

1. *Does physician specialty affect patient outcomes that are related to patient safety?* There is sufficient evidence to conclude that physicians with specialty training experience lower rates of fatal and non-fatal adverse outcomes for certain procedures and medical conditions.
2. *Does physician specialty affect the rate of medical errors?* There is insufficient evidence to answer this key question.
3. *Does physician specialty affect the rate of recognition of medical errors after they occur?* There is insufficient evidence to answer this key question.
4. *Does physician specialty affect the probability that adverse events will occur following detected or undetected medical errors?* There is insufficient evidence to answer this key question.
5. *Does the complexity of the plan of care affect whether physician specialty affects patient outcomes that are related to patient safety?* There is insufficient evidence to answer this key question.
6. *Does employee specialization affect measures of service quality in industries other than health care?* No studies were identified that examined professional qualifications similar to those for assessing physician performance, so research in non-healthcare settings was not found to be relevant to this category.

Experience and Educational Qualifications

The experience and educational qualifications of healthcare professionals has been examined in studies conducted in a variety of settings involving both physicians and nurses. The factors addressed in this category include the perceived quality of prior training, the duration of experience, and the efficacy of targeted training on the patient care skills of health professionals. There are 10 studies that provide evidence about the relationship of these factors to measures of patient safety (Evidence Table 4). Eight of the studies examined physician characteristics,[44, 89-95] one study examined nurses,[96] and one study examined physicians, nurses and other clinical staff.[97]

Of the three studies that examined physician experience,[44, 89, 93] none demonstrated that greater duration of physician experience with surgical procedures was associated with lower rates of post-operative complications. These studies also suggest that participation of trainee surgeons in surgical procedures that are supervised by senior surgeons is not associated with higher complication rates, but both studies examining this question studied only a small number of physicians. A study of physicians' ability to recognize physical findings associated with HIV

infection[94] found that general internists and family practitioners who had greater experience caring for HIV patients were better able to identify oral leukoplakia but did not differ from the comparison physicians in two other physical examination skills. The one study that examined the duration of practice of registered nurses[96] found a lower rate of medication errors on patient care units having more experienced nurses. That study also found that care by baccalaureate-prepared registered nurses was not associated with lower rates of medication errors or patient falls, when compared to associate degree registered nurses.

The available evidence does not permit concluding that the perceived quality of prior educational preparation of healthcare professionals affects any aspect of patient safety. For length of experience and targeted training, the following conclusions can be drawn:

1. *Does professional experience affect patient outcomes that are related to patient safety?* There is evidence from one study of registered nurses that longer duration of experience is associated with lower rates of patient falls. The evidence from this single study is not sufficient to conclude that professional experience affects rates of adverse outcomes.
2. *Does professional experience affect the rate of medical errors?* There is evidence from one study of registered nurses that longer clinical experience is associated with lower rates of medication errors. There is not sufficient evidence to conclude that professional experience affects rates of medical errors.
3. *Does professional experience affect the rate of recognition of medical errors after they occur?* There is no evidence on this question.
4. *Does professional experience affect the probability that adverse events will occur following detected or undetected medical errors?* There is no evidence on this question.
5. *Does the complexity of the plan of care influence whether professional experience affects patient outcomes that are related to patient safety?* Two studies of the performance of surgeons found that greater experience was associated with worse outcomes, which is the opposite to the findings of the one study of inpatient nurses. These three studies suggest that care complexity influences the effects of professional experience on patient safety, but the evidence is not sufficient to draw this conclusion.
6. *Does professional experience affect measures of service quality in industries other than health care?* No evidence was identified on this question.

Temporal Factors

Work schedules and lengths of workshifts have received considerable attention in health care, but much of the evidence on these factors comes from research conducted outside of health care. There has been a long interest in the effects of fatigue upon airplane pilots, and the federal government established mandatory restrictions on pilots' work schedules in 1964. More recently, it has been estimated that 58% of long-haul truck accidents are due to fatigue.[98] Work schedules, including assignments to evening, night, or rotating shifts, have been recognized as a potential contributor to fatigue-related accidents, and research in various industries has provided useful information.[99, 100]

A major focus of fatigue-related problems in health care has been the work schedules of trainee physicians.[98] A systematic review of the effects of fatigue among resident physicians found that there is limited evidence to conclude that fatigue causes higher rates of errors on repetitive tasks and tasks requiring prolonged vigilance.[101] This evidence has contributed to

regulatory efforts to limit work hours of trainee physicians. Although there have been case reports of adverse patient outcomes attributed to resident fatigue,[98] we found no controlled studies of the effect of physician work schedules on measures of patient safety.

Temporal factors related to workforce staffing have been examined in nine studies that provide evidence about aspects of patient safety (Evidence Table 5).[102-110] These studies have been conducted in both healthcare and non-healthcare settings and have examined a variety of questions including the effects of length of work shift, variation in outcomes during days of the week, comparison of day and night shifts, and effects of season of the year. The strongest evidence on the effects of shift length comes from a study conducted among workers in natural gas utility plants.[102] This was a prospective study that examined changes in experimental measures of cognitive function and motor skills before and after workers' changes in shift assignments. That study demonstrated that performance was poorer with 12-hour shifts than 8-hour shifts. A second study examining this question was conducted among German intensive care unit physicians.[104] That study found no difference in complication rates of patients after the physician coverage changed from two 12-hour shifts per day to three 8-hour shifts per day.

There is limited evidence that work schedules requiring changing shifts affects error rates. A survey of registered nurses and licensed vocational nurses examined estimated rates of medication errors for nurses who worked fixed or rotating shifts.[106] Nurses who rotated among shifts reported the highest rate of medication errors. Night shift nurses reported more near miss medication errors than day-shift nurses but no more actual medication errors. A study conducted among factory workers found that rotating shift workers had higher rates of reported workplace injuries.[107] A study conducted in a nuclear power plant[108] found poorer measures of performance among the night-shift workers. However that study was flawed because of a small sample size and limited generalizibility to other settings.

Other studies have examined whether period of the week or year may affect measures of patient safety. A retrospective cohort study conducted in Canada compared patients admitted on weekend days to patients admitted during weekdays.[103] That study found that patients who were admitted on weekends for a variety of principal diagnoses experienced higher in-hospital mortality. However for many other diagnoses, the mortality rates were not different. This study has suggestive findings, but it is not adequate to draw conclusions about weekly variation because of a poorly developed conceptual model regarding the classification of diagnoses. It also is not possible to determine from this study what actual aspects of patient care may be responsible for the reported differences.

Booker and Roseman[105] examined seasonal variation in medication error rates in a 140-bed acute care hospital in Alaska, where the length of darkness ranges from 18.6 hours per day in December to 4.5 hours per day in June. These investigators used existing independently collected hospital data from 1985 through 1989 on medication errors and nine potentially confounding variables, including nursing job vacancies, new nursing hires, amount of overtime, number of temporary worker shifts, leave taken by nurses, number of admissions, number of discharges, total monthly inpatient days, and monthly patient deaths. The relationship between these variables and the monthly average time of darkness per day was examined using Poisson regression analysis. After controlling for measures of workload, seasonal variation in medication errors persisted. Over the 5 years of data they examined, medication error rates were greatest one to two months after the month of greatest darkness.

The following conclusions can be drawn regarding the influence of temporal factors:

1. *Do temporal factors affect patient outcomes that are related to patient safety?* There is evidence from one study that the shift length of physicians is not associated with differences in patient outcomes. The evidence from this one study is insufficient to answer this question.
2. *Do temporal factors affect the rate of medical errors?* There is evidence from one study of non-healthcare workers and a survey study of nurses that performance errors are higher among workers having rotating shift assignments. The studies of 8-hour vs. 12-hour shifts have had conflicting results, but studies conducted among resident physicians have found adverse effects of longer shifts on technical performance. A single Alaskan study found a higher rate of medication errors during the winter season. This evidence is suggestive that rotating shift assignments or longer work shifts are associated with higher rates of medical errors, but it is not sufficient to reach this conclusion.
3. *Do temporal factors affect the rate of recognition of medical errors after they occur?* There is evidence from one study that near-miss errors are more frequently recognized among night-shift nurses, but this evidence is insufficient to answer this question.
4. *Do temporal factors affect the probability that adverse events will occur following detected or undetected medical errors?* There is no evidence on this question.
5. *Does the complexity of the plan of care influence whether temporal factors affect patient outcomes that are related to patient safety?* There is no evidence on this question.
6. *Do temporal factors affect measures of service quality in industries other than health care?* Five of the studies that provided valid evidence on temporal factors were performed in non-healthcare settings.

Workflow Design

Workflow design includes healthcare tasks and workplace design issues relevant to accomplishing the tasks. The key words used in the literature search represent potential domains or conditions in task design (complexity, redundancy, distraction, hand-offs, monotony, and role definition) and in workplace design (shared work space, ergonomics, forced posture, technology, information technology, and equipment). We focused our review in areas of workflow design that had observational or experimental data and that were not already reviewed in the recently published evidence report, *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*.[14] Several important areas of workflow design are "patient safety practices" and were comprehensively reviewed in that report. Aspects of workflow design reviewed in that evidence report and excluded from this review include information transfer, role definition of pharmacists and intensivists, medical devices, computerized physician order entry with clinical decision support, adverse drug events detection and alerts, unit-dose drug distribution systems, automated medication dispensing devices, bar coding, and clinical decision support systems. Because we did not identify data supporting an association between shared workspace or forced posture and medical errors or patient safety, those aspects of workflow design are not covered in the present report.

Task Complexity

Reducing task complexity has been identified as an important strategy to reduce medical errors.[4] However, we did not identify direct observational or experimental data in health care or

other industries supporting the association between task complexity and medical errors or patient safety. General information is available in the psychology and healthcare literatures to support a conceptual framework to explain why task complexity might increase medical errors. The framework is described in the "Transitions or Hand-offs During Care" section below.

Monotony and Redundancy

We did not identify observational or experimental data supporting a connection between monotony or redundancy and medical errors or patient safety. This working condition is discussed in the aviation and anesthesia literature, where tasks have been described as "hours of boredom interspersed by moments of terror."[111] Anesthesia tasks include high workload during times of induction and emergence from the anesthetic state. The maintenance period between these two tasks is a lower workload state requiring vigilance and monitoring skills. Practicing anesthesiologists describe adding other tasks during these periods to avoid boredom and lack of vigilance. [111] Other domains of health care that feature task monotony and redundancy include telemetry monitoring, dialysis, cytology, and transfusion medicine.

Interruptions and Distractions

The management of mental workload or "attentional dynamics" is an important cognitive factor that affects the performance of workers in complex settings. An interruption is generally defined as an external factor causing the cessation of productive activity, before a current task is complete. A distraction is defined as a stimulus from an external source that results in an observable response but not the cessation of activity.[112] A distraction is alternatively defined as preoccupation by one task to the exclusion of others.[113] Interruptions and distractions appear to affect "prospective memory," or the ability to remember to do something that must be deferred.[114] We depend upon prospective memory for tasks for which we do not receive a cue to remember. This type of memory is associated with the context in which it was formed, and changing the context, or in this case getting distracted, impedes recalling the memory. It may take 10-40 seconds to forget to do something upon distraction unless it is strongly connected to a cue.[113] Reason[3] described the phenomenon as belonging to a particular class of errors that he called "omissions following interruptions." Temporary losses of memory, such as when you enter a room and forget why you went there, are known as "activation errors" and are thought to be due frequently to interruptions.[115]

Cognitive research supports that a second task processed concurrently with another task can lead to "interference" or a bottleneck in human information processing.[116, 117] Interference occurs when the resources required of each task overlap. Most people can do two things at once successfully only in very specific task type combinations. Regularly practiced or "automatic" tasks can successfully be paired, such as taking a patient history and formulating a differential diagnosis. "Consciously processed" tasks require more deliberate and sequential thought. This type of information processing is used for more novel or difficult tasks, and these tasks usually cannot be paired without risking error.[114]

Research on interruptions and distractions has been conducted in non-healthcare settings. Lapses of attention have been found to contribute to many aviation accidents.[113] In an analysis of 37 major aviation accidents from 1978-1990, interruptions, distractions, or the preoccupation with one task to the exclusion of another have been determined to play a role in nearly one-half

of flight crew incidents.[114] Often in aviation, the crew becomes pre-occupied with one task to the exclusion of another important one. As an example, Dornheim[114] describes a 1972 crash of an Eastern Airlines L-1011 after the crew became preoccupied with a landing gear problem and failed to notice that the autopilot had become disconnected. In an analysis of 107 reports to NASA's Aviation Safety Reporting System involving competing tasks, radio communication among the crew was the largest cause of distraction (68 of 107 incidents). Most discussions were relevant to the flight but could have been deferred. The main task that was neglected was monitoring the status of the aircraft or the pilot's flying (69 percent of cases).[114]

A study in the nuclear power plant industry revealed that in more than 15 percent of plant shutdowns, operators had been distracted during execution of the current task.[118] In a study among commercial telecommunications workers, interruptions to customers' calls resulted in an increase in the processing time required for the current task, a significant effect of temporal strain on performance, and an increase in the error rate at the beginning of processing the second task.[119]

The commercial airline industry has developed a multi-faceted approach to deal with interruptions, distractions, or the preoccupation with one task to the exclusion of another. The industry has developed a concept known as the "sterile cockpit." Take-off and landing were determined to be critical safety sensitive times. Thus, an administrative procedure forbids the flight crew from talking about anything unrelated to flying when the plane is below 10,000 feet.[120] Surveillance for violations is possible because everything that is said in the cockpit is recorded. The most successful interventions also may not rely upon human memory or behavior. Many approaches to human error among aviation crews address cognitive frailty through improved design of the technology-human interface, also called human factors engineering. An example is the change in equipment that led to the development of a noticeable electronic indicator of the disconnection of the autopilot function.[114] These practices have been adopted by the aviation industry primarily because of their face validity. Although it is difficult to connect evidence to a single intervention, the airline industry has an impressive safety record, with only about 125 deaths/year from $20x10^7$ passenger boardings.[121]

Multiple studies in a variety of settings have demonstrated that health professionals experience frequent interruptions and distractions in the course of patient care. Surveys of residents in pediatrics[122] and internal medicine[123-125] as well as time-motion observational studies of interns[124] have documented how frequently pagers interrupt physicians in training in the course of patient care. Studies of emergency physicians in multiple hospitals have demonstrated high rates of interruptions and competing attentional demands of simultaneous patient care.[126-128] Similarly findings of frequent interruptions and simultaneous demands competing for attention have been demonstrated for nurses in the United Kingdom.[129] Other studies suggest that the frequency of interruptions can be reduced.[130]

Few well-designed studies have analyzed the extent to which interruptions and distractions contribute to medical errors and adverse patient outcomes. We identified six observational studies, one with a concurrent control group and greatest design suitability (comparison of interrupted and uninterrupted prescription dispenses),[112] one with a concurrent control group and moderate design suitability,[134] and the other four without controls and of the least or moderate design suitability (Evidence Table 6).[121, 131-133] Peterson[131] conducted a cross-sectional survey of Tasmanian pharmacists addressing their perceived temporal trend in medication errors and the factors that contribute to or minimize the risk of medication dispensing errors. Flynn[112] examined medication dispensing using videotaped task analysis and a measure of distractibility,

the group embedded figures test (GEFT), to determine the effect of distractibility and interruptions and distractions on medication dispensing errors. Ely[133] performed a cross-sectional evaluation of a focus group and in-depth interviews with family physicians in Eastern Iowa to explore causes of their most memorable errors. Gladstone[132] carried out a retrospective analysis of drug error incident reports and interviews with nurses and managers. Cooper[121] performed a retrospective critical incident analysis of anesthesia errors and equipment failures using structured interviews and a voluntary reporting form. The study findings are outlined in Evidence Table 6.

A quasi-experimental study[134] conducted at a mid-sized acute care hospital in a city in Southeastern Texas measured the effect of two interventions to decrease nurses' distractions during medication administration. Twenty-four medication administration cycles were observed among LPNs and RNs. A control group used customary medication administration procedures. One intervention group used a protocol that specified no conversation during medication administration, teamwork, and a checklist. The second intervention group used the Medsafe intervention, which included the same procedures as the first intervention and added wearing a special vest to indicate to others that distractions were not acceptable during medication administration. The intervention groups had significantly reduced distractions as compared to the control group.

There is sufficient evidence that interruptions and distractions play a role in medication dispensing errors.[112] The evidence of effectiveness of interventions to reduce medication dispensing errors through the reduction of interruptions and distractions is insufficient.[134] The evidence of the association between interruptions and distractions and errors in other areas of medicine is insufficient. This is based upon the limited number of observational studies, three of which rely upon the distant memory of errors.[121, 132, 133]

Interventions to reduce interruptions could be quite simple and inexpensive to implement, as exemplified by those described by Pape.[134] Others have suggested the use of message boards or voice or electronic mail messages for non-urgent messaging, all of which are already commonly available in many healthcare environments.[122]

Transitions or "Hand-Offs" During Care

Individuals with chronic illness often require care from different practitioners in multiple settings. For example, in a given month, the same person with chronic illness may receive care from his or her primary care physician or a specialist in the ambulatory setting, a hospitalist physician and nursing team during an inpatient admission, a different physician and nursing team during a brief stay in a skilled nursing facility, and a visiting nurse in the home. Yet during these times when these patients are most vulnerable and their informal caregivers are often overwhelmed, systems of care may fail them by not ensuring that: (1) the critical elements of their care plan developed in one setting are transferred to the next; and (2) the essential steps that need to take place before and after transfer are executed. In particular, hospital discharge has been identified as a vulnerable time for medical errors and adverse events, and numerous programs have attempted to bridge the gap between the inpatient and outpatient setting.

Transitions between care settings are very common in older adults. In a 2-year study of patients aged 65 or older, 18 percent had at least one post-acute or long-term care transition.[135] Twelve percent of transitions had a followup emergency room visit, an "avoidable hospitalization," or both. A transition was defined as a change in location lasting a day or more

with the place of origin or destination a rehabilitation facility, a nursing home, formal home care, or other formal care setting. The unplanned readmission rate for elderly patients in the first month after discharge is approximately 6 percent, and hospital readmissions of Medicare recipients represent at least one quarter of all admissions.[136, 137] Readmission rates of elderly patients of 25-40 percent within 12 months have been observed.[138]

The risk of errors during transitions from the inpatient to outpatient setting may have increased as the average length of hospital stay for older adults has continued to decline. This trend began with the implementation of Medicare's Prospective Payment System in 1983, and the number of elders discharged with unresolved health problems has increased.[139, 140] If the workflow design does not adequately provide the tools for healthcare workers to exchange information and responsibility successfully, early discharge could be expected to result in higher rates of medical errors and/or adverse events.

Considering how common hospital discharge is we found relatively few studies addressing the rates of errors and adverse events at hospital discharge. More information was available on process gaps. In a secondary analysis of results from a hospital discharge program, barriers to care that had to be addressed during hospital discharge included multiple health providers, multiple settings, and multiple insurers.[141] In a survey of 70 randomly selected patients seen in the general medicine clinic within 2 months of discharge from the inpatient medicine service at the Mount Sinai Medical Center in New York,[142], 52 percent had at least one medication error, 13 percent had at least one test followup error, 7 percent had at least one error in "work-up" or diagnostic evaluation, and 59 percent had an error in one or more of the three categories. The average number of discharge medications among patients with medication errors was significantly higher than those without medication errors (7.2 vs. 5.1, p=0.001). In a similar study, Diem[143] found 10 percent medication and 2.8 percent test scheduling errors at a resident discharge clinic 10 days after hospital discharge.

Discontinuities and inconsistencies between inpatient and outpatient medications, errors in medication labeling, poor patient understanding, and lack of medication adherence after discharge are important sources of errors, especially in the elderly.[144-147] A summary of this area and a review of inpatient to outpatient pharmacy communication interventions can be found in *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*.[14] Murff[148] noted that in elderly patients, hospital providers changed 53 percent of the drugs prescribed in the outpatient setting, and 32 percent of medications prescribed at discharge were not being taken 2 days after discharge. In a Scottish study of elderly patients given a 5-day supply of medication at hospital discharge and visited 5 days after discharge, 27 percent had not received continuing prescriptions for their medications, and among new prescriptions issued, 19 percent were inaccurately labeled.[145]

Gaps in physician-patient communication at discharge appear to be common. In two studies from the US and Canada, 20 percent of patients discharged from the hospital reported that they were not told about important medication side effects nor when they could resume normal activities.[149, 150] Calkins et al.[151] surveyed 99 patients who had been recently discharged from an academic medical center in Boston and their attending physicians. Physicians reported that 89 percent of the patients understood the potential side effects of their medications, but only 59 percent of patients reported understanding ($p<.001$). Physicians reported that 95 percent of patients understood when to resume normal activities, but only 58 percent of patients reported that they understood ($p<.001$).

The gaps in processes surrounding hospital discharge may be important to patient outcomes. Brook et al.[152] evaluated through chart review and patient interview 403 consecutively discharged patients from the medical service of a Baltimore teaching hospital and found that 30 percent received follow-up care rated as inadequate. There was frequent lack of communication of hospital records (34 percent of 124 with private physicians), and 25 (6 percent) were not given follow-up care. In 39 patients (10 percent), a poorer outcome was judged to be due to inadequate care. Inadequate process was associated with poorer outcome ($p<0.01$).

Patients likely contribute substantially to errors during transition. As trends have moved toward shorter hospital stays, increasingly complex medication regimens, and community-based long-term care, the opportunity for important miscommunications and gaps in expected followup have increased. By default, facilitating successful care transitions becomes the responsibility of patients and their caregivers, who may not possess the necessary skills or confidence for this role. A qualitative study of the needs of the elderly in the first week after hospital discharge revealed needs in four major areas: continuing care needs, the need for an available and able caregiver, caregiver uncertainty, and the need for information.[153]

A number of other process gaps have been identified around discharge planning, exchange of information, and transfer of responsibility. These include patients being told at the last moment that they were being discharged, with subsequent insufficient information about the requirements for care; and inadequacy of the discharge plan, patient and caregiver understanding of the plan, and essential resources, e.g., money or transportation.[139, 154]

Many complex factors have been associated with gaps in planning the transition from the inpatient to the outpatient setting. Multiple factors were significantly associated with less adequate social worker ratings of discharge plans in 286 older patients with Medicare: financial impediments, patient confusion, lack of family availability, difficulties working with families, Medicare/ Medicaid guidelines, and team disagreement regarding the patient's psychosocial situation.[155] In a random sample of 133 elderly patients with unplanned readmission to a UK hospital, factors associated with readmission included relapse of the original condition, development of a new problem, caregiver problems, complications of the initial illness, need for terminal care, problems with medication, and problems with service.[136] In that study, service problems significantly associated with readmission included "too early" discharge, in the general practitioner's opinion; no advice given at discharge; and no discharge notice given to the general practitioner. Another study of factors associated with hospital readmission of elderly patients found unavoidable medical deterioration, inadequate medical management, patient non-compliance, social problems, and inadequate rehabilitation as significant.[156]

Is discharge planning effective in reducing errors? A recent Cochrane review (last updated in August, 2000) reviewed 8 controlled trials of discharge planning involving 4837 patients.[157] Four trials recruited patients with a particular medical condition and four recruited patients with a mix of medical and surgical conditions. There was a small reduction in hospital length of stay for elderly medical patients allocated to discharge planning (weighted mean difference -1.01, 95% CI -2.06 to 0.05), but overall the results of the trials were mixed.

We extended the findings of the Cochrane review by evaluating interventions that did not focus on a particular medical condition and had an outpatient component. We identified 10 randomized controlled trials and four observational studies of hospital discharge programs for the aged that met our criteria (i.e., were not single disease focused and had an outpatient component to the intervention). The trials are summarized in Evidence Table 7. All designs were rated to have the greatest suitability. The average patient age in all studies was $\geq$65 except

for Smith,[158] where the average age was 52. The studies were conducted at Veterans Affairs hospitals,[143, 159] a community hospital in the UK,[160, 161] US, [162] or Denmark,[163] and academic medical centers.[141, 158, 164, 165]

Lipton[162] utilized pharmacists to prevent medication errors. The other interventions were delivered by nurses,[141, 158, 164] a nurse practitioner and geriatrics team,[165] nurses and health care assistants,[161] a nurse and a primary care physician,[159, 163] medical residents,[143] or a care attendant,[160] and provided support for multiple aspects of care, including medication. The intervention intensity was variable as outlined in the table, with dedicated staff in six studies[141, 160-162, 164, 165] and staff given additional responsibilities in four studies.[143, 158, 159, 163] Length of outpatient intervention followup was variable, with 1 week,[158, 159] 10 days,[143] 2 weeks,[160, 163, 164] 4 weeks,[141] 6 weeks,[161] 3 months[162] or unclear length of followup.[165]

Most studies did not provide detailed information about the types of interventions provided by staff. Naylor[139] did describe six strategies that were utilized by the advanced practice nurses: comparing patient and caregiver data, anticipating outcomes, individualizing care, empowering patients and caregivers, crossing barriers, and creating solutions.[139] Two-thirds of the nurses' interventions were in the surveillance area, which included initial assessment and ongoing monitoring. Teaching, guiding, and counseling comprised 20 percent of the interventions, case management 14 percent, and treatments and procedures 1 percent. Clinical outcomes included mortality,[143, 160, 163, 165] non-elective hospital admission,[141, 143, 158-161, 163-165] time to first hospital readmission,[141, 164] length of hospital stay,[164] nursing home admission,[161, 163, 165] morale,[160] quality of life[159, 165] and physical independence.[160] Other outcomes included medication errors,[162] emergency room utilization,[143] and satisfaction.[159, 165]

All ten studies of hospital discharge programs for the aged are rated good for their quality of execution, but the evidence for their effectiveness is mixed. This may be in part due to the large variation in intervention design and intensity. Six studies utilized dedicated staff, [141, 160, 161, 162, 164, 165] and four studies utilized nondedicated staff.[143, 158, 159, 163] Of the trials with dedicated staff for the intervention five of six had a positive impact on readmission rates or a related outcome. Of the trials without dedicated staff (i.e., additional tasks for existing staff), one of the four had a positive impact and one of the four had an increase in readmissions in the intervention group.

We also found three observational studies evaluating transitional programs at hospital discharge in older adults. In a project that employed a liaison nurse before and after hospital discharge in the Dutch Zaandam region, a pre- and post-questionnaire to patients suggested that the quality of discharge planning was improved.[154] Significant results were achieved in the areas of need for aftercare discussed with patients, home health staff being informed, and patients taught about proper handling of surgical dressings. In a survey of registered nurses, the absence of medication discharge planning for elderly patients with congestive heart failure was significantly associated with hospital readmission ($p<0.05$).[166]

Patients discharged from a UK teaching hospital who received an informational booklet about their care at discharge were more likely to know the medications they were taking and the correct dose and frequency than patients who did not receive the booklet.[167] Sixty of 165 elderly patients consecutively discharged from the hospital that received pharmacist counseling made less than one-third of the medication errors made by the uncounseled group.[168]

This body of evidence is sufficient to conclude that hospital discharge programs employing a dedicated staff and having an outpatient component reduce readmission rates and hospital days. However, the evidence is not sufficient to conclude that these programs reduce medical errors and associated adverse events, because these studies did not report these outcomes. While it is

possible that higher readmission rates are associated with worse patient outcomes, the small amount of evidence on this point is insufficient to permit any conclusion. In the one study reporting an increase in readmissions[159], patients in the intervention group had higher satisfaction and no decrement in quality of life relative to controls. Conversely, an intervention that reduced readmission rates also had no effect on functional status.[141]

Weinberger[169] evaluated the cost-effectiveness of the Smith[158] intervention described above. High-risk patients in the intervention group had significantly higher outpatient costs ($131/month vs. $107/month; p=0.02) but lower inpatient costs ($535/month vs. $800/month; p=0.02) than the control group.

Naylor[164] found that 6 weeks after hospital discharge the mean charge for the intervention group was 63 percent less than the mean charge for the control group. In the 1999 Naylor study,[141] at 24 weeks after discharge, total Medicare reimbursements for health services were $1.2 million in the control group vs. $.6 million in the intervention group (p<.001).

Other transitions in care may contribute to medical errors and adverse events. We found one study of medication dispensing for a random sample of over 50,000 Medicare registrants in Quebec in 1990.[170] This study concluded that the greater the number of prescribing physicians, the greater the risk was that the patient received a potentially inappropriate drug combination.

Computer Interface Design

Clinical decision support systems have been shown to be effective in reducing nosocomial infections,[171-173] improving dosing of nephrotoxic medications,[171-173] and accelerating recognition of serious laboratory abnormalities.[171-173] Computerized physician order entry has been shown to reduce the incidence of adverse drug events.[13] Alerts, reminders, and other decision support features have been demonstrated to reduce errors in prescribing,[174, 175] improve preventive and chronic disease care, and improve physician and patient satisfaction in controlled settings or inpatient environments.[172, 174-178] A recent review concluded that vigorous application of alerts and reminders could substantially reduce mortality for multiple conditions.[175]

Caution is appropriate, however, before widespread deployment of information systems meant to improve the reporting and reduce the occurrence of medical errors.[14] Lessons from other domains, including aviation and military applications, suggest that information systems may sometimes worsen the situation. Problems include such phenomena as "automation surprise," when computer systems designed for typical conditions behave unpredictably under conditions of stress or crisis; "automation complacency," where situation awareness is reduced when pilots are removed from the information loop by automation; and "mode confusion," where it is not clear to the human operators which mode of operation the automated system has assumed. Extensive research in the military, aviation, and nuclear power industries documents such dysfunctional interaction between information systems and the individuals they are meant to assist[179] and investigations of aviation accidents confirms the difficulty of designing software that helps rather than hinders expert decision makers in urgent, complex, uncertain conditions.[180]

Ongoing research in human performance with complex systems in high reliability domains emphasizes how information systems must function as team players that interact effectively with other members of a team to collaboratively manage complex situations.[181] This collaboration requires understanding not only the traditional one-to-one human-computer interaction of traditional human factors studies, but also the complex situation that arises when the technology is added to existing teams of humans.

Two studies have examined computer interface design in health care, and neither evaluated medical errors nor patient safety. One study compared nurses' response time, errors, and satisfaction comparing text-based computer interface to prototype graphical interface. The nurses had significantly faster response times, fewer user errors and were more satisfied with the graphical interface.[182] The second paper is a case study of the implementation of a "user-centered" computerized command-and-control system in an ambulance service that concluded that there was an improvement in time to ambulance-on-the scene and lower subjective anxiety and systolic blood pressure in the workers after system implementation.[183]

Summary of Key Questions for Workflow Design

1. *Do workflow design working conditions affect patient outcomes that are related to patient safety?* The evidence for the association between workflow design factors and patient safety has focused on the incidence of medical errors and such adverse events as re-hospitalization but not adverse patient outcomes. There is insufficient evidence to conclude that workflow design factors affect the incidence of adverse outcomes.
2. *Do workflow design working conditions affect the rate of medical errors?* There is sufficient evidence to conclude that interruptions and distractions increase the incidence of medication dispensing errors. The strength of the body of evidence for the association between hospital discharge factors and medical errors is also sufficient. The evidence that pharmacist discharge programs can reduce medication errors in the elderly is sufficient. The other areas reviewed had insufficient evidence.
3. *Do workflow design working conditions affect the rate of recognition of medical errors after they occur?* There is insufficient evidence to support this in all areas reviewed.
4. *Do workflow design working conditions affect the probability that adverse events will occur following detected or undetected medical errors?* There is insufficient evidence to support this in all areas reviewed.
5. *Does the complexity of the plan of care affect whether workflow design working conditions affect patient outcomes that are related to patient safety?* There is insufficient evidence to support this in all areas reviewed.
6. *Do workflow design working conditions affect measures of service quality in industries other than health care?* There is insufficient evidence to support this in all areas reviewed.

Personal/Social Working Conditions

This section of the report is concerned with the evidence for a relationship between the personal, professional, or social aspects of the healthcare work environment and the safety of patient care. The underlying assumption is that the ability of health professionals to provide safe patient care will be influenced by personal factors such as stress, burnout, and job dissatisfaction; social factors such as collectivism or discord within a work group; or professionalism in the form of the ethics and values that are cultivated within a professional discipline such as nursing, pharmacy, or medicine. Studies focusing on the effects of these conditions at the individual or work group level are included in this section, while studies focusing on the broader organization and its organizational structure or culture are included in the subsequent section on organizational factors.

This report is restricted to direct evidence regarding the impact of these working conditions on patient safety or medical error. It is beyond the scope of this report to review the vast literature that exists on the effects of these working conditions on other variables, including their physiologic, metabolic, and psychological effects in individual workers or their organizational effects such as absenteeism or job turnover. By way of background, several of the relevant constructs are briefly described below.

Stress is a construct that refers to one's response to an imbalance between the expectations or demands placed on individuals and the resources or capacities available to meet them. Stress has been defined in the research literature as a stimulus variable, an intervening variable, and a response variable.[184] In an extensive review of stress and its physiologic, metabolic, and psychologic sequelae, Levine[185] notes that a) stress-related decrements in performance have been replicated across a wide range of stressors and populations in laboratory tasks; b) interventions that increase control and predictability are effective in reducing these effects; c) evidence for these performance effects is largely based on laboratory studies, and evidence in naturalistic settings is limited; and d) a pervasive finding in the literature is the curvilinear ("inverted U") relationship, whereby arousal is associated with improvements in performance, while stress is associated with performance decrements. Jones, however, emphasizes the multidimensional nature of the stress-performance relationship, concluding that stress effects are situation-specific, individual-specific, and task-specific.[186]

Burnout has been described as a state characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment, especially prevalent in human-service related occupations, with consequences on job satisfaction and performance that have been evaluated in a wide range of occupations and professions.[187] Burnout may be distinguished from stress in that burnout refers to a longer lasting, more stable condition while stress is generally, though not always, more transitory. Burnout is distinguished from depression in that burnout involves a person's relationship to their work, while depression has pervasive effects on multiple aspects of an individual's life.

The potential relationship between job satisfaction and job performance has been a subject of intense investigation by industrial psychologists for many decades, but the research remains inconclusive. In a critical review of this literature, Judge et al. examine seven potential models of this relationship and found the literature to be inconsistent, in part due to the piecemeal nature of the research, with many models being proposed but no systematic and coherent approach to thoroughly testing them.[188] Based on a meta-analysis of 312 studies, these authors conclude that a relationship does exist and propose a multidimensional model as a basis for future research.

Social dimensions of the work environment include collectivism, the belief of a group member that one's individual welfare is closely tied to that of the group.[189] According to this construct, individual behavior and overall group performance are potentially affected by the degree of collectivism in a work group. A related concept, work group cohesion, has been identified as an important determinant of job satisfaction.[190] Social support has been identified as one of the factors that can mitigate stress-related effects on performance.[185]

Professionalism may also impact the ability to provide safe patient care. Health professionals include themselves among the learned professions, espousing values such as excellence, altruism, and personal accountability.[191] Teaching these values is incorporated into their training and symbolized by recitations of the discipline's oath at graduation or other ceremonies. Maintaining these values is an ongoing activity within the profession, as evidenced by

publications that respond to perceived threats to these values by redefining professionalism and/or calling for its renewal.[192, 193]

To impact patient safety, working conditions must affect health professionals, this effect on health professionals must interfere with or alter their clinical work practices, and the altered work practices must result in harm to patients. As an example, working conditions might produce stress or burnout among clinicians such as physicians, nurses, or pharmacists. Clinicians with stress or burnout may thereby be more likely to make medication errors. Medication errors, in turn, may result in harm to patients. Steps in this theoretical chain of causation are independent, and every step in the chain must be present for an impact on patient safety to occur. This allows for the possibility that a working condition can affect health professionals without affecting clinical practices, or that clinical practices may be affected without necessarily resulting in harm to patients.

Eleven studies provide evidence pertinent to the effects of personal/social working conditions and are summarized in Evidence Tables 8 and 9. Five studies reported on the impact of stress on patient safety[194, 195] (one single publication[195] reported results of four distinct, original studies). Four studies were concerned with the impact of dissatisfaction and burnout.[196-199] Two reported on the effects of social aspects of the work environment.[189, 200] These studies are grouped together by topic and discussed individually.

Stress in the Hospital Work Environment

Two publications reported five studies related to stress in the hospital work environment.[194, 195] Three of these were cross-sectional studies examining the association of stress levels with rates of malpractice claims (Evidence Table 8, top frame). The last two evaluated stress reduction interventions (Evidence Table 8, lower frame).

Dugan et al.[194] examined the relationship between stress among hospital nurses, burnout indicators, nursing injuries, and patient incidents in a moderate sized hospital in the Midwest United States. Stress was measured using reported stress symptoms and a single item measure of perceived stress, but response rates to the mailed survey were low. Prospectively collected hospital department data were used for burnout indicators (unit-level sick leave, other absences, and turnover), nursing injuries (nursing needle-stick and back injuries), and patient incidents (medication errors, IV errors, and patient falls). Data were aggregated for comparison at the level of hospital units, which included a broad spectrum of hospital nursing care. Correlation between the two stress measures was only 0.59, indicating that convergent validity was less than expected. Medication errors and patient falls were found to be significantly associated with perceived stress but not with reported stress symptoms. Intravenous administration errors were not correlated with either measure of stress, nor were nursing injuries or burnout indicators. This study provides only weak evidence of a relationship between perceived stress and medication errors or patient falls.

Jones et al.[195] in a single publication reported the results of four studies examining the relationship of job stress and patient safety. Study 1 examined the relationship between the malpractice risk of 91 departments of five hospitals and stress in those departments. Stress was measured with the Human Factors Inventory, which included subscales for job stress, organizational stress, job satisfaction, and personal stress. High malpractice risk departments were defined as those having one or more malpractice claims attributed to human error in the preceding year or were identified as having unacceptable clinical practices in interviews with at

least two hospital personnel. The 13 high malpractice risk departments had significantly higher scores than the 78 low malpractice risk departments for job stress, job dissatisfaction, and organizational stress, but not for personal stress. In a repeat analysis comparing the 13 high-risk departments with 13 low risk departments matched for the acuity of patient care provided in those departments, the finding persisted, suggesting that the findings are independent of the type of department or the acuity of care provided therein. These data suggest an association between job stress, organizational stress, and job dissatisfaction in a hospital department and the malpractice risk experienced by that department, although the direction of causation is uncertain.

The second study in the report by Jones et al.[195] examined the relationship between the malpractice experience of hospitals and the average level of stress measured among the hospital's employees. Aggregate hospital scores for job stress, organizational stress, and job dissatisfaction were highly correlated with one another and with a hospital's malpractice claims experience, while personal stress was not. After controlling for number of hospital beds, job stress and organizational stress remained significantly correlated with malpractice claims experience, while personal stress and job dissatisfaction were not. These data suggest an association between employee stress and the malpractice claims brought against those hospitals. High stress could be the cause of clinical practices associated with higher malpractice risk, but malpractice claims also could be the cause of higher employee stress.

Two studies of a stress management intervention were also reported by Jones. Based on analysis of stress data obtained using the Human Factors Inventory, a five part program was implemented, including 1) high level management information and feedback about hospital employee stress scores; 2) departmental modifications in communication, organization, and personnel policies implemented by managers of high stress departments working with consultants; 3) feedback sessions with employees about stress levels and stress management; 4) viewing of stress management training videocassettes by hospital employees; and 5) a program for employee counseling and assistance. A pilot pre-/post-intervention study (Study 3) demonstrated that the frequency of medication errors dropped by half after implementation of the program at a single hospital, but did not attempt to document that the intervention reduced employee stress levels. The fourth study, a nonrandomized, controlled trial, reported by Jones et al.[195] then assessed the impact of this same stress management program on hospitals' malpractice claims rates. Hospitals agreeing to participate in the trial (n=22) were compared to control hospitals (n=22) matched for size, prior frequency of malpractice claims (the dependent variable in the study), location, and the types of patient care services offered. Following implementation of the stress management programs rates of malpractice claims fell in the intervention hospitals and rose in the control hospitals. The studies found a consistent relationship between employee stress and various measures related to patient safety and provide a strong argument for recommending further research about stress among health professionals and particularly the effects of stress reduction programs conducted in hospitals. The limitations of this trial are (1) the main outcome measure, malpractice claims, is a poor surrogate for patient safety; and (2) because it was not a randomized trial, it is likely that hospitals that adopted the intervention differed from those in the control group.

The limited available evidence on the effects of stress among health professionals does not lead to judgments about sufficient evidence to answer any of the key questions, but the available evidence does suggest that further research is indicated.

1. *Does stress affect patient outcomes that are related to patient safety?* Organizational stress and job stress were associated with higher malpractice risk[195] and patient falls.[194] Malpractice risk was lower in a controlled trial of a stress management program.[195] Malpractice events are a poor measure of patient safety, so there is insufficient evidence to conclude that stress causes increased adverse patient outcomes.
2. *Does stress affect the rate of medical errors?* Separate studies having relatively weak designs found that medication errors were higher on hospital nursing units with high stress[194] and that medication errors fell following implementation of a stress management program.[195] However, there is insufficient evidence to conclude that stress leads directly to medical errors.
3. *Does stress affect the rate of recognition of medical errors after they occur?* No studies addressed this question.
4. *Does stress affect the probability that adverse events will occur following detected or undetected medical errors?* No studies addressed this question.
5. *Does the complexity of the plan of care affect whether stress affects patient outcomes that are related to patient safety?* No studies addressed this question.
6. *Does stress affect measures of service quality in industries other than health care?* No studies addressed this question.

Dissatisfaction and Burnout

Bond and Raehl[196] conducted a survey study to examine the relationships between pharmacists' estimates of the risk of medication dispensing errors and pharmacist worksite, workload, workflow, and job satisfaction. A lower estimated risk of dispensing errors was correlated with pharmacists' satisfaction, including satisfaction with career, working conditions, work hours, time for clinical activities, level of staffing, level of technician support, and level of technician training. Pharmacists estimated a higher risk of dispensing errors under conditions of greater workload (prescriptions per hour) and in certain work sites. A lower estimated risk of dispensing errors was associated with 1) greater clinical time (consulting with physicians, counseling patients, etc.); 2) management time (practice management, committee work, etc.); 3) professional society membership and professional development activities; and 4) longer experience. No consistent pattern was evident between type of worksite and the other variables that were associated with a higher estimated risk of dispensing errors. The strongest predictor of low risk of dispensing errors was the time available for dispensing each prescription.

DeVoe et al.[197] used a survey to examine whether career dissatisfaction was associated with a perceived inability to provide high quality care among family physicians. Nearly 18 percent of the respondents reported dissatisfaction with their career, and dissatisfaction was more frequent among physicians reporting inadequate time spent with patients, inadequate freedom to make decisions that meet patient needs, and overall inability to provide high quality care to patients. Firth-Cozens and Greenhalgh[198] investigated the relationship between self-reported stress and inadequate patient care among physicians practicing in the United Kingdom. These authors collected narrative accounts of circumstances "where stress related symptoms have affected your patient care" and coded the narratives according to a previously developed schema for causes of stress and consequences of stress. Causes of stress in the schema included tiredness, overwork pressure, anxiety/depression, alcohol, and boredom. Consequences of stress in the schema included irritability and anger, a lowered standard of care, serious nonfatal mistakes, and patient

deaths. Physicians in the sample were members of a cohort being followed since medical school in 1984. Of 302 surveys, 255 were returned, 76 of which contained answers to an open-ended question about the impact of stress on care, including 82 narratives. Results of coding these narratives indicated that tiredness (57.4 percent) and pressure from overwork (27.7 percent) were most often cited as causes of inadequate patient care, while depression or anxiety (8.5 percent), the effects of alcohol (5.4 percent) and boredom (1.0 percent) were less frequently indicated. The effects of stress on patient care were mainly a lowered standard of care (50 percent) and irritability and anger (40.2 percent), while serious mistakes (7.4 percent) and patient deaths (2.4 percent) were less frequently reported. Two patient deaths were reported and were attributed to tiredness and pressure from overwork. Six incidents of serious mistakes were reported, four of these were attributed to tiredness and two were attributed to tiredness and overwork. The authors caution that their data are self-report by informants and may be biased by informant perceptions and beliefs, but suggest that their data support a model in which tiredness and overwork interact with stress, self-criticism and lowered standards of care in a self-reinforcing cycle.

Shanafelt et al.[199] examined the relationships among working conditions, resident burnout, and patient care practices. An anonymous survey was mailed to 151 resident physicians in a multi-hospital university training program in the Northwest United States. Three quarters of the respondents met the criteria for burnout. Residents with burnout more frequently reported suboptimal patient care practices (defined as errors in medication or treatment, discharge of patients to reduce team workload, paying inadequate attention to the social or personal impact of illness on a patient, and not fully discussing treatment options or answering a patient's questions). Depersonalization, a subscale of the burnout inventory, exhibited a 'dose-response' relationship with self-reported suboptimal care, while the emotional exhaustion and personal accomplishment subscales were not significantly associated with suboptimal patient care practices. Among residents with burnout, positive depression screen results were more common (44/87 vs. 8/28) as was self reported depression (27/87 vs. 3/28) and career dissatisfaction (36/87 vs. 3/28). Stressors contributing to burnout that were identified most often by residents were inadequate sleep (41 percent), frequent shifts over 24 hours in length (42 percent), and insufficient leisure time (42 percent). Personal coping strategies identified as most helpful in dealing with stress were talking with family (72 percent) or talking with other residents (75 percent). Residency program features identified as most helpful for managing stress were having at least four days off per month (97 percent), the availability of ancillary help for patient care (95 percent), and the presence of night float call system (64 percent).

Leppa[200] examined the relationships among disruption of the nursing unit work group, nurses' job satisfaction, and their perceived quality and safety of patient care. Nurses were surveyed to assess job satisfaction and perceived quality and safety of patient care. Nursing unit work group disruption was assessed by measures of absenteeism, turnover, and degree of agency nurse use. The authors reported a) that nursing unit work group cohesion was most strongly correlated with job satisfaction; b) that nursing unit work group cohesion was inversely related to short-term disruption, indicated by the use of agency nurses, but not to long-term disruption, indicated by new hires, terminations, and transfers; and finally that c) the degree of agency nurse use was inversely related to perceived quality of patient care.

Carey[189] has characterized job satisfaction using a multi-component model that includes error orientation, perceived workload, job control, monotony, collectivism and autonomy. Self-report survey instruments were returned by 209 of 710 nurses from a broad spectrum of nursing work

sites and job types in the United States. The survey combined items from extant validated instruments and scales for the work variables listed. A panel of eight subject matter experts was used to assess nursing work types according to the criticality and pace of care, the expertise required, the expected frequency of errors and crises, the amount of stress, and the degree of autonomy associated with each nursing work type. Error orientation, a recent construct in industrial and organizational psychology, is composed of eight subscales: Error Competence (ability to handle errors); Learning from Errors (learning something that can be applied long term); Error Risk Taking (flexibility and openness to errors; Error Strain (stress experienced when errors are made); Error Anticipation (a pessimistic attitude toward errors; Covering Up Errors (seeing errors as a threat within the organization); Error Communication (telling others and asking for help in correcting errors); and Thinking About Errors (analysis of errors).

Error Orientation was found to be correlated with Job Control and Collectivism, but not with Workload or Monotony, although overall the amount of variance explained in a regression analysis was small. Examining subscales of Error Orientation, Job Control was associated with Error Competency (the ability to handle errors when they occur), Learning from Error (learning something that can be applied in the long term), and Error Risk Taking (flexibility and openness to errors). Collectivism was correlated with Error Communication (telling others and asking for help), Thinking About Errors, and Collectivism was inversely correlated with Error Anticipation (pessimism about errors). Increased Workload was correlated with Covering Up Errors, while Autonomy was associated with Error Risk Taking (flexibility and openness to errors). All data in the study were based on self report, and no external or objective measure of either working conditions or error behavior was included in this study.

Overall, there is weak and inconclusive evidence that health professional burnout and dissatisfaction have a significant impact on patient safety.

1. *Do burnout and dissatisfaction affect patient outcomes that are related to patient safety?* Anecdotal data from qualitative studies suggest that physicians attribute some patient deaths to 'overwork pressure' and tiredness,[198] but the evidence is insufficient to answer this question.
2. *Do burnout and dissatisfaction affect the rate of medical errors?* Surveys suggest that pharmacists' dissatisfaction is associated with higher rates of dispensing errors,[196] that burnout among physicians in training is associated with suboptimal patient care practices,[199] and that among family physicians the inability to provide high quality care is associated with career dissatisfaction. Anecdotal data from qualitative studies suggest that physicians attribute some instances of 'serious mistakes' and lowered standards of care to 'overwork pressure' and tiredness.[198] These results are suggestive that higher levels of burnout and dissatisfaction cause higher rates of medical errors, but the evidence is not sufficient to reach this conclusion.
3. *Do burnout and dissatisfaction affect the rate of recognition of medical errors after they occur?* No studies addressed this question.
4. *Do burnout and dissatisfaction affect the probability that adverse events will occur following detected or undetected medical errors?* No studies addressed this question.
5. *Does the complexity of the plan of care affect whether burnout and dissatisfaction affect patient outcomes that are related to patient safety?* No studies addressed this question.
6. *Does stress affect measures of service quality in industries other than health care?* No studies addressed this question.

Physical Environment

Healthcare professionals spend their workdays in a person-made environment that has many physical characteristics, including color, visual and auditory stimuli, thermal quality, and aesthetics. Research on environmental working conditions has been conducted in a variety of industrial settings, and many reports have provided recommendations on workplace design in both healthcare and office settings.[201-211] These recommendations include a variety of lighting and color techniques to improve workers' efficiency and moods. Other environmental factors advocated for the comfort of workers and patients include the provision of indoor plants, fresh air, controlled temperatures, and the presence of windows. Windows perform several functions including admitting light, ventilation, allowance for vision in and out, and providing aesthetic benefits.

Lighting in the workplace has been conceptualized as visual stimuli. Lighting is central to the human visual system and is measured by luminous flux, luminous intensity, illuminance, and luminance.[212] These characteristics directly affect performance of the human visual system, as well as affecting circadian rhythm and metabolic functions. Aesthetically, it has been proposed that lighting also has an impact on human mood and behavior. However, the exact mechanisms by which light characteristics cause psychological and physiological problems are not fully understood.

The science of color consists of the technique of measurement of color, known as colorimetry, the production of color stimuli, and the visual perception of color. Color consists of many dimensions including saturation, value (lightness/darkness), and hues (warm/cool). Color is measured in wavelengths, with longer wavelength colors (reds, yellows, and oranges) being labeled as "warm colors." Shorter wavelength colors (blues, greens and purples) are labeled "cool colors." Most research on the effects of color on humans has explored the impact of warm and cool colors on human feelings, or affect. Longer wavelength colors are labeled as more exciting, while shorter wavelength colors have a calming or quieting effect. However, there has been limited research on the effects of environmental colors on gross and fine psychomotor activities, physical coordination, and human behaviors.

Auditory stimuli include both noise and sound. Noise has been defined as a change in auditory stimuli that has no relationship to the task that is being performed. On the other hand, sound has been defined as auditory stimuli that provide direction to the task at hand. Both noise and sound are complex variables that consist of continuous and intermittent auditory stimuli and loudness, as measured by decibel levels (dBA). In addition, the control one has over the auditory stimuli and the predictability of auditory stimuli can have an influence on how they are perceived.[213]

Thermal stress includes both hot and cold conditions. Measures of thermal stress include air temperature, wind speeds, and the submersion of one's body, or body parts, into cold or hot conditions.

For more than 100 years there has been interest in the impact of the physical environment on patients' ability to heal.[214] A recent systematic review addressed the impact of the physical environment on patients' health outcomes.[215] Eighty-four studies met inclusion criteria for this review. Eleven of the 84 studies examined the impact of auditory stimuli, or noise, on patient outcomes. The patient outcomes included subjective and objective measures of sleep, anxiety, coping, heart rate and respiratory rhythms. Thirteen of the 84 studies examined the impact of light on patient outcomes. Of these 13 studies, the population studied in eleven was neonates.

Outcomes were presence/absence of conjunctivitis, activity levels, heart rate, respiratory rate, bilirubin, sleep/wake cycles, presence of retinopathy, cortisol levels, and weight gain. The two remaining studies evaluated elderly and psychiatric patients. The first study examined the impact of light on serum vitamin D levels. The second study examined the impact of light on length of hospital stay for psychiatric patients. One study explored the impact of windows, a visual stimulus, on the patient outcome of delirium and depression in an ICU. Thermal stress was the focus of 5 of the 84 studies. The population in all of the thermal stress studies was neonates. The outcomes of interest included water and heat loss, mortality, body temperature, vomiting, edema, weight gain, oxygen consumption, jaundice, and cerebral irritation. None of the studies evaluated the relationship of physical environment factors to healthcare working conditions.

Thirteen studies were found to have evidence relevant for assessing the effects of physical environment characteristics on patient safety (Evidence Table 10).[213, 216-227] Three of these studies were conducted in healthcare settings, and the rest were conducted in a variety of simulated or actual workplaces. One study[216] examined an intervention to reduce both ambient light and noise levels in a neonatal intensive care unit, while the others examined single environmental characteristics. Of the studies examining single factors, two examined effects of noise, one examined the effect of cold temperature, and nine examined the effects of light intensity, environmental colors, or presence of windows.

The three studies conducted in healthcare settings all examined medication errors as a measure of patient safety, although one of the studies[216] also measured adverse outcomes (intravenous infiltration, accidental intubation, nosocomial infections, and mortality). The Walsh-Sukys study evaluated medication errors by nurses, while the two other studies[213, 223] evaluated dispensing errors by pharmacists working in hospital-based pharmacies.

Lighting and Color

Laboratory work conducted prior to the 1960s forms the basis of most current recommendations on workplace lighting. This work included studies to determine illumination levels that are appropriate for various tasks, quality of illumination such as brightness and glare, uniformity of illumination, and quantity of illumination. A review of this older literature by Megaw[212] found that there is a relationship between lighting and human performance, but it is confounded by individual characteristics, such as age, hormonal influences, eye functioning, and by task dimensions.

The intensity of workplace lighting has been found to affect the incidence of dispensing errors by pharmacists. Buchanan, et al.[223] found that a markedly increased level of workplace lighting was associated with a 30 percent reduction in the rate of medication dispensing errors. Although only five pharmacists were studied, the benefit of the high lighting level was observed for all five of the study subjects. This study also found no difference in error rates between two lower levels of workplace lighting. Another recent study[216] examined whether reducing levels of lighting in a neonatal intensive care unit affected the incidence of medication errors by nurses. No significant difference in errors was found between the unit with conventional lighting and the unit with lower lighting. These studies suggest that changing lighting levels within the usual range has little effect on medication errors but that substantially increased lighting may reduce error rates.

Five studies in non-healthcare settings examined the effect of the color of the workplace on human performance.[217, 219-221, 226] All five studies were conducted in simulated office environments, and the subjects were college students who were paid or given course credit for their participation. Four of the studies manipulated the color of walls, and the fifth[217] altered the color of the workplace lighting. Two of the studies found significant relationships between color and work performance, but the direction of the effect was opposite in these two. While it is possible that environmental colors impact healthcare workers differently than office workers, these studies suggest that the effects are minor.

Other visual stimuli that have been proposed to have an impact on human performance are plants and windows. No empirical evidence exists to support the popular notion that plants in the work place have a positive effect on human performance. Three studies examined the impact of windows on human performance.[218, 222, 224] Two of the studies were simulated environments, on college campuses. Both studies failed to find significant effects of windows on performance. One study examined the effect of window shape on human performance.[224] This study reported a significant difference between square and round window shapes, with a square window resulting in less error on an observational task. This well-designed study has limited applicability to healthcare settings but may provide insight into such specific tasks as patient monitoring. The methodological and theoretical approaches of this study could be adapted to future studies in the healthcare setting.

The cumulative evidence on the effects of workplace lighting is not sufficient to provide answers to any of the key questions. The strongest evidence is provided by Buchanan's study[223] that found a positive effect of increased workplace lighting on pharmacists' dispensing errors, but this single study does not provide enough evidence to make a recommendation. However, limited further research should clarify whether this finding can be replicated.

Sound and Noise

Smith[228] reviewed the literature between the years 1950-1990 on the impact of noise on human performance and accidents and concluded that noise could be one of many contributing factors to workplace accidents, but the mechanisms are still not clear. We identified one study conducted in a healthcare setting that evaluated the impact of auditory factors on errors (Evidence Table 10).[213] This observational study was designed to determine the impact of sound and noise on pharmacist error. The pharmacists who participated in the study were aware that they were being studied. The study found that some types of auditory stimuli appeared to decrease error, while other types had no impact. None of the measures of sound or noise were found to be increased in the cases having dispensing errors. Another study examined whether reducing both light levels and noise reduced medication errors and adverse outcomes in a neonatal intensive care unit.[216] It found no significant changes in any of the measures of patient safety. One additional study examined the impact of noise on human performance that used methods comparable to those of studies of working conditions in health care.[225] This study used a cross-sectional design to examine relationships between accident rates and workplace noise levels among male textile workers. No significant differences were found in the incidence, frequency, or severity of accidents between low-noise and high-noise work sites.

The studies on workplace noise provide sufficient evidence to answer one key question:

1. *Do noise levels affect patient outcomes that are related to patient safety?* There is evidence from one study that noise levels do not affect safety-related outcomes, but this is not sufficient to provide a definitive answer to this question.
2. *Do noise levels affect the rate of medical errors?* There is sufficient evidence from studies conducted in both healthcare and non-healthcare settings to conclude that ambient noise levels do not affect the incidence of medication errors.
3. *Do noise levels affect the rate of recognition of medical errors after they occur?* There is insufficient evidence to answer this key question.
4. *Do noise levels affect the probability that adverse events will occur following detected or undetected medical errors?* There is insufficient evidence to answer this key question.
5. *Does the complexity of the plan of care affect whether noise levels affect patient outcomes that are related to patient safety?* There is insufficient evidence to answer this key question.

Environmental Temperature

The impact of thermal stress on human performance has been of central interest to professions that are exposed to extreme conditions, such as those that exist at the South Pole, Antarctica, factories, or work conducted in underwater cold conditions. Previous literature reviews[229-231] have concluded that heat affects performance, but this effect was also influenced by the difficulty and complexity of the task being conducted and by individual characteristics, such as age, sex, fitness levels, skill levels, experience, and training. Enander[232] and Enander and Hygge[233] reviewed the effects of cold on human performance and found that, while there is evidence of adverse effects of cold temperature, further methodological and theoretical work is necessary in this area.

We identified no studies examining high levels of heat on human performance relevant to health care, but we identified one study that examined the impact of moderate cold on performance.[227] This study found that cold temperatures impair manual dexterity, which could be relevant to performance of medical procedures in external environments (such as some aspects of the work of emergency medical technicians).

The cumulative evidence on the effects of environmental temperature is not sufficient to provide answers to any of the key questions. The strongest evidence is provided by one study that found manual dexterity to be reduced in a cold environment. This study was conducted using non-healthcare tasks in a simulated environment and does not provide strong enough evidence to make a recommendation.

Organizational Factors

Organizational factors are structural and process aspects of the organization as a whole. For example, work structures such as division of labor or use of teams are organizational factors with potential influences on patient safety. Other organization-level factors include facility size, funding mechanisms (e.g., profit, not-for-profit), hospital type (e.g., teaching, private), and culture. Some organizational factors, such as size and funding base, are difficult to change, while others, such as organizational culture, can be changed through systematic initiatives.

In non-healthcare industries such as aviation and nuclear power, organizational factors have been identified as important for safety improvement.[234-236] Health care has also moved to a

perspective that involves analysis of the organizational system within which errors occur and development of system-level responses.[237-239] A systems perspective requires a focus upon the conditions and processes involved in the delivery of care and examination of how each step in the process contributes to both desired and adverse outcomes. This approach employs failure analysis strategies such as root cause analysis[240, 241] and information management technologies in the analysis and solution of error.[13, 242] In addition to the view that error results from the processes and procedures is the view that considers larger system culture, structure, and the context of practice. In this approach organizational culture and professional perceptions are emphasized.[243]

As health care has focused safety efforts toward the system within which care is delivered and away from the individual provider of care, a terminology of organizational factors has emerged, as evidenced by such phrases as culture of blame, [244, 245] culture of silence, [246, 247] and culture of safety.[248-250] These phrases indicate a clear belief that something about the work environment and in the context of the work itself influences positively and/or negatively the occurrence of errors and adverse events. The non-routine and sophisticated technologies, professional staffs, and dynamic environments found in health care necessitate culture management. [251] Despite culture's importance in high reliability systems,[252, 253] research into the relationship between organizational culture and patient safety remains sparse.

Early studies of the influence of organizational working conditions on patient safety examined magnet hospitals. Spurred by the nursing shortage of the mid 1980s, a number of studies of nursing indicated a need for greater involvement by nurses in hospital governance and working conditions.[254] Concurrently, the American Academy of Nursing examined characteristics of 41 hospitals that, despite the national scarcity of professional nurses, were successful in recruiting and retaining nurses. These hospitals were termed "magnet hospitals" for their ability to attract sufficient nursing staff to maintain high staffing levels.[255] Studies of these hospitals[256, 257] found that several organizational level elements were critical: autonomy, participative management, and support of professional development, relatively high organizational status of nursing, and collaboration.

Much of the difficulty in examining the role of cultural factors in patient safety results from definitional ambiguity. Culture and climate are often used interchangeably and may represent different approaches to measurement of the same phenomenon.[258] Organizational culture definitions are multiple and varied but generally characterize culture as the shared values, norms, and tacit assumptions of members within an organization, while others include more tangible characteristics such as social practices and capacities in the definition.[259]

Current studies define climate specifically, such as safety climate or lateness climate.[260] Further definitional ambiguity is added by use of other terms such as work environment, practice environment, work context, and job context.[261] To add another layer of complexity to the understanding of culture and patient safety is the need to consider national, professional, and organizational cultures[262] in addition to the subcultures within organizations. As workplaces become more diverse, these differing (and perhaps conflicting) types of culture become more salient. For the purposes of this evidence review, culture is defined broadly. Organizational working conditions refer to culture and climate as well as larger organizational influences such as structure.

The International Nuclear Safety Advisory Group (INSAG) coined the term safety culture in response to the Chernobyl incident and defines it broadly as organizational attitudes and structures that place overriding priority on safe plant operations.[263] The Veterans Health

Administration has operationalized a culture of safety that reflects the INSAG definition through 1) public commitments to improving patient safety, 2) resources for special centers, 3) employee education, and 4) incentives to promote safety.[249] Pizzi[264] has identified four factors from the literature that characterize a safety culture: 1) recognition of the risk of error in the organization's activities, 2) blame free environment for reporting, 3) collaboration across the organization, and 4) organizational resources for safety.

Our literature search yielded 19 studies of organizational factors that influence patient safety, and these studies are pertinent to four of the five key questions. Thirteen of the 19 studies provide evidence on the influence of organizational culture on patient safety (Evidence Table 11).[42, 260, 262, 265-274] The other six studies provide evidence about various other organizational factors, such as hospital ownership, team structure, and division of labor(Evidence Table 11).[43, 275-279]

Multiple studies have found that measures of organizational culture are related to the incidence of adverse patient outcomes. Shortell and colleagues[265] examined several organizational variables and organizational culture (using a culture instrument) in relation to various patient outcomes, including quality of care and risk-adjusted mortality. The study used selected items from a standard culture instrument, the Organizational Culture Inventory (OCI), and found significant differences across the hospitals sampled in the patient endpoints. However, little of the variation was associated with the culture measure. A second study[266] compared 39 magnet hospitals with 195 matched controls and observed 4.6 percent lower mortality (adjusted for patient composition) for Medicare patients in magnet hospitals as compared to nonmagnet hospitals. This supports a conclusion that organizational factors such as hospital-level differences in the organization of nursing care have a significant impact on patient outcomes. In a study of AIDS inpatient units, Aiken and her colleagues described favorable patient outcomes associated with a nursing practice environment characteristic of those found in magnet hospitals, including greater responsibility for decision-making and more egalitarian interprofessional relationships.[42] Jones and Redmond used the OCI in a prospective study of organizational redesign in three hospitals.[272] In this study the hospital most successful with redesign efforts and with higher nurse and patient satisfaction scores had a balanced culture, that is, a culture that exhibits characteristics of control and flexibility as well as internal and external focus. The other two hospitals had increases in Hierarchical (rule and procedure driven with control orientation and internal focus) and Market (outcome and market share driven with control orientation and external focus) orientations and concomitant decreases in satisfaction scores. However, this study had inadequate measures of patient outcomes.

A qualitative study[268] of accidents and near misses in an emergency department revealed that two organizational factors (division of labor and power differentials) contributed to the adverse events through poor communication. While these factors or latent conditions existed throughout the organization, the authors attributed the adverse effects on patient safety as especially problematic in an emergency department. This study is suggestive of the negative impact of structural-cultural factors upon patient safety. However it did not examine cases without adverse events in relation to the identified organizational factors and cannot be considered adequate evidence of the negative impact of these factors.

Two cross-sectional studies[43, 279] examined the relationship between organizational factors (hospital ownership and whether or not the hospital was a teaching facility) and mortality rates. Bond and his colleagues[43] found that private ownership (either non-profit or for-profit) was associated with lower overall mortality rates. Teaching status per se was not associated with

mortality rates, but size of the medical residency program was inversely related to overall mortality rates. Schultz and her colleagues[279] also did not find a significant relationship between teaching status and mortality rates among patients with acute myocardial infarction. Significant differences were found for the financial status of the hospitals, with nonprofit hospitals having a lower mortality rate. Both of these studies are limited by having inadequate measures of patient casemix, which limits their value as evidence regarding the effect of these organizational factors on patient safety.

A study that measured organizational culture using standard instruments examined the relationship of culture to what may be considered intervening variables in a model of patient safety. The study[274] used the OCI to gather culture data but did not directly measure the relationship between culture and outcomes. Culture type was associated with quality improvement (QI) implementation, and QI implementation was associated with better patient outcomes (scale included errors and inappropriate treatment). Because this study did not measure direct relationships, it provides only limited evidence on the effect of organizational culture on patient safety measures.

Three studies have examined the recognition and reporting of medication errors in relation to organizational culture. A recent survey study[271] examined culture in relation to medication error reporting. Using a standard measure of culture, the Culture Inventory, there were significant differences in cultures among hospitals, with the larger hospitals tending toward more hierarchical cultures, which are formalized and highly structured, focusing on rules and procedures. Correlations between culture and medication error reporting were non-significant, although in the expected direction, with hierarchical cultures negatively associated and group cultures (those more people-focused) positively associated with reporting. An earlier study[269] used qualitative methods (interview and observation) to assess several aspects of social or unit climate and reporting of errors. A unit ranking on "openness" made by the researcher blind to the quantitative results was matched with detected unit error rates. In general, lower detected error rates occurred on the units with the less open climates. The third study,[273] a phenomenological exploration of registered nurses' reporting of wrongdoing, identified several themes linked with either professional or organizational culture. Nurses' reporting was associated with hospital policies, consequences, professional ideals, and workplace dynamics. While these three studies provide insight into the use of measurement tools for organizational culture, they do not provide sufficient evidence to conclude that organizational culture affects reporting of errors.

Organizational factors have been extensively studied in industries other than health care. One of the largest studies on the influence of national, organizational, and professional cultures upon safety in the aviation industry is that of Helmreich and Merritt.[262] Using a modification of a well-accepted tool for assessing national culture, and expanding existing human factors questionnaires to measure organizational culture and attitudes, the researchers found that specific aspects of culture had significant impact upon error management. There were extensive data on airline crews, especially airline cockpit crews and lesser data on operating rooms. A study of utility company work crews showed a negative correlation between both the cooperation and quality climate subscales and accidents.[260] While using empowerment rather than culture as a variable, a study of chemical company work teams found significant correlation between empowerment and both safe behaviors and accidents; as empowerment increased, safe behaviors increased and accidents decreased.[270] In a study of inattention as a cause of railway accidents in Australia, Edkins & Pollack[276] found that a poor work environment of low morale and other organizational factors contributed to railway accidents. They recommended actions towards

improving the safety culture to decrease inattention errors. A meta-analysis of employee satisfaction and engagement[277] demonstrated a correlation between engagement and safety outcomes across 739 business units in 36 companies. However, an Australian study of values and safety behavior in hairdressers found no support for an effect of manager and employee prevention values on safety behavior.[267]

Two studies in non-healthcare industries showed a positive effect of the use of teams. The first,[275] showed that teamwork and goal setting (compared to goal setting alone) had a significant positive effect on the quality of ore excavated from a silver mine. The second,[278] showed a significant inverse relationship between the use of teams and injury rates in small manufacturing firms.

The multiple studies of organizational factors have used diverse methodologies and have examined a great variety of workplace settings. While they do not provide sufficient evidence to answer any of the key questions, they provide direction to further research in this area.

1. *Do organizational working conditions affect patient outcomes that are related to patient safety?* The studies examining the relationship between organizational culture and the incidence of adverse patient outcomes had inconsistent results, and there are too few studies of other organizational factors to provide sufficient evidence to conclude that any organizational factor has a significant effect on adverse outcomes. Nevertheless, the findings of the studies described above provide a useful framework for further studies to answer this question.
2. *Do organizational working conditions affect the rate of medical errors?* There is insufficient evidence to answer this question.
3. *Do organizational working conditions affect the rate of recognition and reporting of medical errors after they occur?* Three studies provided evidence suggesting that elements of organizational culture affect error-reporting rates, but the cumulative evidence is not sufficient to answer this question.
4. *Do organizational working conditions affect the probability that adverse events will occur after detected or undetected medical errors?* No studies were identified that contributed evidence for this question.
6. *Do organizational working conditions affect service quality in industries other than health care?* A variety of organizational factors have been studied in multiple industries, and these results are highly suggestive that organizational factors affect service quality. However, because of the variety of measurement techniques for both organizational factors and outcomes, there is not sufficient evidence to identify individual factors that could be applied to health care.

Chapter 4. Conclusions

Evidence About the Effects of Healthcare Working Conditions

A diverse body of research conducted in both healthcare and other workplace settings provides evidence about how working conditions affect processes relevant to patient safety. Most of the research has been observational, but there have also been useful experimental studies examining some aspects of workflow design and environmental factors. For all categories of working conditions examined in this report, there is evidence that provides guidance for patient safety improvement. However, as summarized in the individual sections of Chapter 3, the sufficiency of evidence to draw clear conclusions varies considerably among the categories. The strongest evidence for a direct relationship between working conditions and patient safety is in the domains of workforce staffing and workflow design. In the domain of physical environment, it has been demonstrated that ambient noise is not a threat to patient safety. The research on personal/social and organizational working conditions is insufficient to answer any of the key questions, but the available evidence in these domains provides useful guidance for future research (discussed further in Chapter 5).

The field of working conditions encompasses a wide range of specific factors, and it is not surprising that the research has tended to focus on certain factors, to the exclusion of others. The evidence on how working conditions affect patient safety is limited to certain specific types of working conditions and to certain healthcare delivery settings. However, the cumulative evidence demonstrates that working conditions are important in influencing patient safety and deserve careful attention from healthcare professionals.

In Chapter 3 the evidence was summarized for the specific areas of working conditions addressed in this report. In this chapter each key question will be reviewed to summarize the overall evidence across all areas of working conditions.

Key Question 1. Do Working Conditions Affect Patient Outcomes that are Related to Patient Safety?

The largest body of available evidence was found to apply to this key question. Many observational studies have examined a variety of working conditions and patient outcomes related to adverse events, such as in-hospital mortality, nosocomial infections, and decubitus ulcers. A common finding across multiple studies examining this question is that the evidence is strongest for such non-fatal outcomes as newly acquired infections and short-term re-hospitalizations. Evidence for a direct effect of any working condition upon patient death is suggestive but relatively weak. For example, in a retrospective review of 1,609 sentinel events among hospitalized patients, inadequate nurse staffing was reported to be a contributing factor in 24 percent.[60] However, in multiple studies that have examined nurse to patient ratios and mortality rates in inpatient settings, a consistent effect of nurse staffing on patient mortality has not been found. Part of this discrepancy is probably due to the fact that mortality is only partly related to patient safety problems. For analyzing patient safety, an adverse outcome is considered to be an injury caused by health care rather than by the underlying disease. Patient

deaths are often due to overwhelming disease, and casemix measures do not adequately control for this mode of causation. Medical errors can cause excess deaths over and above those caused by disease, but methods for attributing cause of death have not yet been developed for studies of the effects of working conditions on mortality. Although the present available evidence does not permit the conclusion that changes in working conditions will lead directly to lower patient mortality, the data are sufficient to assert that selected changes in some working conditions are likely to lead to lower rates of non-fatal patient outcomes that are related to patient safety.

In studies examining both acute care hospitals and nursing homes, the mechanisms by which patient safety is affected appear to be similar across these healthcare settings. However, initiatives to improve patient safety need to be based upon data applicable to specific settings. For example, guidelines for sufficient nurse to patient ratios will differ greatly among intensive care units, non-intensive acute care units, and nursing homes.

Key Question 2. Do Working Conditions Affect the Rate of Medical Errors?

The evidence about the relationships between individual working conditions and rates of medical errors is diverse. Based on evidence from cross-sectional studies that measured error rates and retrospective analyses of reported medical errors, we concluded there is sufficient evidence that some working conditions, including patient-to-nurse ratios and workplace interruptions, affect rates of certain medical errors. There also is highly suggestive evidence that other factors, such as environmental lighting, affect error rates. The types of error studied have been limited. Most evidence pertains to medication administration and dispensing errors by nurses and pharmacists. There has been very little research conducted on many other important areas of error, including breaks in precautions to prevent worker-involved transmission of infectious agents among patients and technical errors in operative procedures. Studies of error rates among physicians have mostly been conducted in simulated care delivery settings. A common feature of nearly all studies of error rates is that the errors involve simple calculation and recording tasks. Potentially important but more complex types of error, such as prioritizing clinical tasks or developing diagnostic assessments, have not been studied in the context of working conditions.

Key Question 3. Do Working Conditions Affect the Rate of Recognition of Medical Errors after they Occur?

Recognition and reporting of medical errors have been emphasized as part of patient safety improvement programs.[262] Our systematic literature review yielded only limited evidence that working conditions are related to error recognition and reporting. Some aspects of workforce staffing (shift scheduling) and organizational factors were found to affect error reporting.

Key Question 4. Do Working Conditions Affect the Probability that Adverse Events will Occur Following Detected or Undetected Medical Errors?

The ideal study of working conditions would be a prospective evaluation that examined healthcare delivery sites with systematically different working conditions and recorded both medical errors and relevant clinical outcomes. Such a study would test whether working conditions influenced the relationships among errors and patient outcomes. Unfortunately, no such studies have yet been conducted. There have been studies that examined both medical errors and adverse outcomes, but they have not provided the detail of results to evaluate whether medical errors led directly to adverse outcomes. Thus, there is insufficient evidence to answer this key question for any type of working condition at this time.

Key Question 5. Does the Complexity of the Plan of Care Affect Whether Working Conditions Affect Patient Outcomes that are Related to Patient Safety?

Answering this question requires that research be conducted in a broad enough range of healthcare settings to permit synthesis of findings across settings. The body of research on working conditions research has been conducted in a wide variety of settings and has examined a large number of clinical problems. For selected working conditions, there is sufficient evidence to answer this question. Findings about the effect of patient to nurse ratios on adverse event rates has been sufficient to conclude that the magnitude of the effect differs between intensive care and general inpatient care settings. Studies of physician workload have not demonstrated that the complexity of the clinical environment influence the effect of procedural volume on adverse event rates, but the range of physician practices examined in these studies has been limited. Many types of physician work have not been studied. These findings suggest that extrapolations across clinical settings should be made with caution and need to be guided by empirical research.

Key Question 6. Do Working Conditions Affect Measures of Service Quality in Industries Other than Health Care?

Research in non-healthcare settings provides useful evidence for evaluating several areas of working conditions. Research on the effects of ambient noise in factories has provided evidence comparable to that from healthcare settings and has permitted us to judge the evidence to be sufficient to conclude that ambient noise does not affect patient safety. Most research on workplace colors and aesthetics has been conducted outside of healthcare but is sufficiently comparable to conclude that these factors also do not affect patient safety. Research conducted on organizational factors outside of health care also has been complementary to healthcare studies and contributes to a growing level of knowledge in this domain.

These examples illustrate that research conducted outside of health care is particularly useful for answering questions about patient safety that have not been adequately studied in healthcare settings. If there is sufficient evidence to answer a key question for a particular healthcare working condition, then further evidence from outside health care is interesting but not necessary. In contrast, insight into key questions that do not have sufficient evidence from

healthcare settings could be provided by non-healthcare research. Incorporating evidence from other industries requires careful analysis of whether the non-healthcare work is similar enough to healthcare tasks that generalization of the findings to health care is valid. The similarity of work is particularly important for aspects of workflow design. There is a large body of research on workflow design in non-healthcare settings such as aviation, but there are not yet well accepted criteria for applying much of this work to health care, where work processes are highly specialized to meet patient care needs. Thus, we found many areas of working conditions for which non-healthcare research could not be applied.

Key questions 3 and 4 have the lowest level of available evidence from healthcare settings. These key questions pertain to the recognition and effects of medical errors. There is inadequate research in non-healthcare settings on errors that can be generalized to health care. It is not yet understood whether error patterns in settings such as simulated aviation cockpits can be generalized to health care. Thus, non-healthcare research did not contribute evidence to answer these two key questions.

Clinical and Health Policy Implications of the Findings on the Effects of Healthcare Working Conditions

The systematic literature review conducted for this report provided sufficient evidence to make specific recommendations about strategies for improving patient safety. These recommendations can be summarized as follows.

- Strategies to increase staffing levels of licensed and unlicensed nurses in both acute care hospitals and nursing homes will likely lead to improved patient outcomes.

- Preventable complications are lower when complex technical procedures are performed by high-volume physicians.

- Duration of experience of the health professional is associated with better patient outcomes for some types of clinical care.

- Systems to reduce interruptions and distractions will likely reduce the incidence of medical errors.

- Systems to improve information exchange, transfer of responsibility, and continuity of care between hospital and non-hospital settings ("hand offs") decrease medication errors and in some settings hospital re-admissions.

- Levels of ambient noise in healthcare settings do not adversely affect patient safety.

Chapter 5. Future Research

With the exception of selected work processes pertaining to workflow design, most of the evidence on the relationship of working conditions to patient safety is derived from non-experimental studies. Thus, there remain unanswered questions about the magnitude of improvement in patient safety that will be brought by efforts to improve working conditions. There is a need for significant future research that evaluates how specific workplace interventions will be related to changes in patient outcomes. Such research could be conducted as clinical trials or as carefully designed demonstration projects and program evaluation studies.

The available evidence on working conditions also suggests a variety of specific studies that will provide further information on how working conditions affect patient safety. Some examples of the questions to be addressed in future studies are as follows:

- *How does greater nursing experience affect improved patient outcomes?* Is it due to the direct patient care or through advice and other collaborative mechanisms among experienced nurses and less experienced members of inpatient care teams?

- Previous research has found that both the number of registered nurses and the number of total nursing personnel are associated with improved patient safety. *What is the appropriate mix of registered nurses and unlicensed personnel? What are the most effective collaborative models of nursing practice?*

- The evidence suggests that rotating shifts and possibly longer shift lengths are a threat to patient safety. *What scheduling models optimally balance scheduling needs with reduction of medical errors?*

- Previous research on the relationship of stress and patient safety has used weak measures of safety variables. Future research using better measures of patient safety is needed.

- A single study[223] has found that increasing the level of workplace lighting decreased error rates by dispensing pharmacists. Further research conducted in a variety of work settings is needed to evaluate this potential approach to reducing errors that can be implemented widely at relatively modest cost.

- Studies of the relationship of organizational factors to patient safety have used only limited measures of organizational factors. Further research with valid measures of a wide range of organizational factors is needed.

- There is limited evidence that greater experience of health professionals is associated with improved patient safety. Further research to examine this association and potential benefits of enhanced training programs for less experienced providers is needed.

- Further research is needed to quantify the types, frequency, and severity of interruptions and distractions in safety-sensitive areas in health care. Incidents of human error should be carefully analyzed for preventable precursors, such as conflicting task requirements,

distractions, and interruptions.[280] In addition, studies are needed to elucidate further how interruptions and distractions affect medical errors and adverse events. Research is needed to assess the effect of interventions on interruptions and distractions, error rates, adverse events, and patient and physician satisfaction.

- Research is needed to develop and study hospital discharge programs that focus on the root causes of poor outcomes. Further research is needed to determine whether successful programs are transferable to other settings. It would also be useful to study existing or previously implemented hospital discharge programs to understand how they affect medical errors. If existing hospital discharge programs work predominantly through active and not latent error reduction, then risk still remains in the system, especially for patients not eligible for the program.

- Research in interface design supports matching system performance to operator needs in order to improve job performance.[281] The human factors community has argued strongly for further research in this area for some time.[281-284] This community recognizes the need for user-driven design, and displays configured to the user's need to avoid errors.[282] Often, there is more concern with obtaining the most up-to-date technology without concern for how to support operators in their tasks.[284] Others have supported a research effort in interface design in medicine of similar intensity to that seen in other safety sensitive industries, such as aviation and nuclear power.[111]

- There is limited evidence that stress among health professionals has an adverse impact on patient safety, and further research on measuring stress and interventions to mitigate stress in healthcare work environments will help to clarify the importance of this working condition.

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Evidence Table 1. Nurse staffing

Author Year	Study Question(s)	Design	Setting	Category of Health Professional
Amaravadi 2000[46]	Is a higher nurse to patient ratio in ICUs associated with lower preventable complications?	Cross-sectional	ICUs in 35 Maryland hospitals	Nurses
Aiken 1999[42]	Is higher nurse to patient ratio associated with lower mortality among hospitalized AIDS patients?	Cross-sectional	2 inpatient nursing units in each of 20 U.S. hospitals	Nursing staff
Lichtig 1999[42]	Are RN staffing levels associated with rates of inpatient adverse events?	Cross-sectional	462 California and 229 New York acute care hospitals	RNs and total nursing staff
Anderson 1998[48]	Do nursing homes with better patient outcomes have higher levels of nurse staffing?	Cross-sectional	494 Texas nursing homes	RNs, LVNs, and nursing aides
Shortell 1994[50]	Is a higher nurse to patient ratio in ICUs associated with lower in-hospital mortality?	Cross-sectional	1-2 ICUs in each of 40 hospitals; U.S. nationwide sample	Nurses
Aiken 2002[66]	Is a higher nurse to patient ratio associated with lower 30-day mortality for patients undergoing surgical procedures?	Cross-sectional	168 Pennsylvania hospitals	Registered nurses
Kovner 2002[69]	Are staffing levels by RNs and LPNs associated with rates of adverse events for surgical patients?	Cross-sectional	570 US acute care hospitals	RNs and LPNs
Needleman 2002[52]	Are lower staffing levels associated with complications?	Cross-sectional	799 hospitals in 11 U.S. states	RNs, LPNs, and nursing aides

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Working Condition	Measure of Safety	Casemix Control
Amaravadi 2000[46]	Estimated ratio of nurses to patients during night shifts	Infections, cardiac arrest, re-intubation, and in-hospital death	ICD-9 codes, age, sex
Aiken 1999[42]	Nurse to patient ratio	Mortality within 30 days of admission	AIDS severity and prognostic measures and ADL
Lichtig 1999[42]	Total nursing hours and percentage of hours performed by RNs	Decubiti and in-hospital infections	ICD-9 codes, nursing intensity weights
Anderson 1998[48]	Ratio of nursing staff hours to patient days	Incidence of decubiti, UTIs, and fractures	ADLs and selected diagnoses
Shortell 1994[50]	Estimated ratio of nurses to patients	In-hospital death	APACHE III
Aiken 2002[66]	Estimated ratio of nurses to patients	30-day mortality	Demographic variables and ICD-9 codes
Kovner 2002[69]	Nursing hours per patient day	Post-operative thromboses, pulmonary complications, and UTIs	Analysis restricted to patients with defined diagnoses
Needleman 2002[52]	Nursing hours per patient day	Infections, bleeding, shock, cardiac arrest, and death	ICD-9 codes, age, sex

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Main Finding	Design Suitability/ Study Execution
Amaravadi 2000[46]	Units with ratios of more than 2 patients per nurse had higher rates of infections but no difference in the rates of the other complications.	Greatest FAIR
Aiken 1999[42]	Higher nurse to patient ratio was associated with lower mortality.	Greatest FAIR
Lichtig 1999[42]	In New York hospitals, higher levels of total nursing and RN hours were associated with lower rates of pressure ulcers but not nosocomial infection rates. In California hospitals, higher levels of total nursing hours were associated with lower rates of pressure ulcers and pneumonia. In California hospitals, higher levels of RN hours were associated with lower rates of all complications. Total nursing hours were not associated with complication rates. Higher percentage of RNs was associated with lower rates in California but not New York.	Greatest FAIR
Anderson 1998[48]	Higher RN and aide staffing was associated with better outcomes.	Greatest FAIR
Shortell 1994[50]	No association between staffing ratio and mortality.	Greatest FAIR
Aiken 2002[66]	Patients in hospitals with higher estimated nurse to patient ratios had slightly lower 30-day mortality (95% confidence interval of odds ratio 1.02-1.11).	Moderate GOOD
Kovner 2002[69]	Greater RN hours were significantly associated with lower rates of pneumonia but not with rates of the other adverse events. LPN hours were not associated with adverse event rates.	Moderate FAIR
Needleman 2002[52]	In-hospital complications were lower with higher staffing, but in-hospital death did not vary.	Moderate GOOD

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Study Question(s)	Design	Setting	Category of Health Professional
Bolton 2001[61]	Are lower ratios of licensed nurse/non-licensed caregivers associated with higher rates of pressure ulcers and falls?	Cross-sectional	Inpatient units of 38 California acute care hospitals	Nurses and non-licensed caregivers
CMS 2001[67]	Are nursing home staffing ratios and staff turnover associated with incidence of nosocomial infections, pressure ulcers, and weight loss?	Cross-sectional	5,294 nursing homes in 10 states	RNs, LPNs, and nursing aides
Dimick 2001[53]	Is a lower nurse to patient ratio in the ICU associated with higher rates of adverse outcomes after hepatectomy?	Cross-sectional	33 Maryland acute care hospitals	Nursing staff
Pronovost 2001[54]	Do hospitals with higher nurse to patient ratios in ICUs have lower complication rates after surgery for abdominal aortic aneurysm?	Cross-sectional	38 Maryland acute care hospitals	ICU nursing staff
HCFA 2000[68]	Are nursing home staffing ratios associated with incidence of pressure ulcers and nosocomial infections?	Cross-sectional	1,786 nursing homes in three states	RNs, LPNs, and nursing aides
Tarnow-Mordi 2000[55]	Is in-hospital mortality higher when more patients in an ICU have fixed nurse staffing?	Time series N=1050 patients	ICU of one hospital in Scotland	Nursing staff
Bond 1999[43]	Are staffing levels of RNs, LVNs, and pharmacists associated with in-hospital mortality rates?	Cross-sectional	3,763 U.S. hospitals	Nursing and pharmacy staff
Blegen 1998[49]	Are lower staffing levels associated with higher rates of medication errors and adverse events?	Cross-sectional	42 inpatient units of a single university hospital	Nurses and non-licensed caregivers

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Working Condition	Measure of Safety	Casemix Control
Bolton 2001[61]	Ratio of licensed to non-licensed caregivers	Fall rates and pressure ulcer prevalence	None
CMS 2001[67]	Ratio of each category of nursing staff to patients	UTIs, sepsis, pressure ulcers, and weight loss	ICD-9 codes, race, age, body mass index, and ADLs
Dimick 2001[53]	Nurse to patient ratio estimated by ICU director	In-hospital mortality and post-operative pulmonary and infectious complications	ICD-9 codes and demographic factors
Pronovost 2001[54]	Nurse to patient ratio estimated by ICU director	Multiple post-operative complications derived from ICD-9 codes	Age, sex, race, severity of illnes and ICD-9 codes
HCFA 2000[68]	Ratio of each category of nursing staff to patients	Respiratory infections, UTIs, sepsis, and pressure ulcers	ICD-9 codes
Tarnow-Mordi 2000[55]	Total number of patients in ICU	In-hospital mortality	APACHE II
Bond 1999[43]	Number of full-time RNs, LVNs, and pharmacists	In-hospital mortality	ICU days, ER visits and Medicaid usage
Blegen 1998[49]	Nursing hours per patient day and proportion of nursing hours delivered by RNs	Rates of medication errors, falls, decubiti, in-hospital deaths, and urinary or respiratory infections	Patient acuity measure

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Main Finding	Design Suitability/ Study Execution
Bolton 2001[61]	No difference in fall rates and pressure ulcer prevalence existed between hospital units with >70% RN care and units with <50% RN care.	Moderate FAIR
CMS 2001[67]	Nursing homes with the highest staffing ratios for all three categories of nursing staff had the lowest rates of all measures of adverse events. Facilities with higher turnover of nursing assistants had higher rates of UTIs and pressure ulcers.	Moderate GOOD
Dimick 2001[53]	ICU nurse staffing was not consistently associated with complication rates.	Moderate FAIR
Pronovost 2001[54]	All medical complication rates were higher in hospitals reporting lower ICU nurse to patient ratios.	Moderate FAIR
HCFA 2000[68]	Nursing homes with the lowest staff to patient ratios had the highest rates of all measures of adverse events, for all three categories of nursing staff. The relationships were stronger for nursing aides and LPNs than for RNs.	Moderate GOOD
Tarnow-Mordi 2000[55]	Mortality rates were higher when ICU census was higher.	Moderate FAIR
Bond 1999[43]	RN and pharmacist staffing were associated with lower mortality. LVN staffing was associated with higher mortality.	Moderate FAIR
Blegen 1998[49]	Non-intensive care nursing units having a higher ratio of RN care had lower rates of medication errors and decubiti. Intensive care units had higher rates of these complications and the highest ratios of RN care.	Moderate GOOD

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Study Question(s)	Design	Setting	Category of Health Professional
Blegen and Vaughn 1998[56]	Are lower staffing levels associated with preventable complications?	Cross-sectional	11 U.S. Hospitals	Nurses, LPNs, and nursing assistants
Kovner 1998[57]	Are RN staffing levels associated with rates of in-patient adverse events?	Cross-sectional	589 U.S. hospitals in 10 states	RNs
American Nurses Association 1997[58]	Is nurse staffing lower in hospitals having higher rates of decubiti and infections?	Cross-sectional	502 hospitals in California, Massachusetts, and New York	RNs, LVNs, LPNs, and nursing aides
Tutuarima 1993[59]	Is nursing availability lower for patients who fall than for other patients?	Case-control study of 49 hospitalized stroke patients who fell and 49 who did not	9 Dutch hospitals	Nursing staff
Hartz 1989[64]	Do hospitals with higher percentages of registered nurses have lower in-hospital mortality?	Cross-sectional	Nationwide HCFA data on 3,100 hospitals	Nursing staff
Flood 1988[51]	Are adverse events higher on a short-staffed inpatient unit?	Cross-sectional	2 inpatient nursing units in a single U.S. hospital; same number of beds & equal occupancy	RNs, LPNs, and nursing aides
JCAHO 2002[60]	Are nurse staffing problems identified in reports of sentinel events among inpatients?	Case series of 1,609 sentinel events reported to JCAHO	U.S. hospitals	Nursing staff

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Working Condition	Measure of Safety	Casemix Control
Blegen and Vaughn 1998[56]	Nursing hours per patient day	Medication administration errors, falls, and cardiopulmonary arrests	Type of nursing unit
Kovner 1998[57]	Number of RNs per patient day	Hospital-acquired infections and thromboses	ICD-9 codes
American Nurses Association 1997[58]	Nursing hours per patient day and RN hours per patient day	Decubiti and hospital-acquired infections	Nursing intensity weights
Tutuarima 1993[59]	Patient to nurse ratio	Inpatient fall	Gender, age, and clinical severity of stroke
Hartz 1989[64]	Percentage of nurses who are registered	In-hospital mortality	ICU days
Flood 1988[51]	Average number of nursing staff per month	Nosocomial infections, cardiac complications, and gastrointestinal disorders	Nursing acuity level
JCAHO 2002[60]	Nursing staff levels	Unanticipated events leading to death, injury, or permanent loss of function	None

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Main Finding	Design Suitability/ Study Execution
Blegen and Vaughn 1998[56]	Medication errors were higher with higher staffing levels. Units with the highest proportion of RN staffing had higher medication error rates. Higher RN staffing levels were associated with fewer falls.	Moderate FAIR
Kovner 1998[57]	Higher RN staffing was associated with lower rates of post-operative infections.	Moderate FAIR
American Nurses Association 1997[58]	Higher RN hours but not total nursing hours were associated with lower decubiti rates in two of the three states. Infection rates were not consistently associated with nursing hours.	Moderate FAIR
Tutuarima 1993[59]	Nursing ratio was no different between cases and controls.	Moderate POOR
Hartz 1989[64]	Hospitals with higher ratios of RNs to all nurses had lower average in-hospital mortality.	Moderate FAIR
Flood 1988[51]	The unit with lower staffing had a higher incidence of complications.	Moderate POOR
JCAHO 2002[60]	Staffing problems were identified as a factor in 24 percent of sentinel event reports.	Least FAIR

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Study Question(s)	Design	Setting	Category of Health Professional
Sochalski 2001[62]	Is higher nursing workload associated with higher rates of medical errors and adverse events?	Survey of registered nurses	50% sample of all licensed Pennsylvania RNs; 52% response rate	9,545 RNs
Byrne 1998[70]	Is a higher intensity of work associated with a larger number of errors on anesthetic record charts?	Time series	British hospital in Cambridge	10 trainee anesthetists
Hunt 1998[63]	Do hospitals with lower nurse to patient ratios have higher rates of adverse events?	Cross-sectional	Nationwide study of 23 hospital trusts in Scotland	Registered nurses
Fridkin 1996[65]	Is nurse staffing lower during an outbreak of inpatient catheter-associated bacteremia?	Time series study during an outbreak of infections	Single DVA hospital	Registered nurses

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Working Condition	Measure of Safety	Casemix Control
Sochalski 2001[62]	Subjective estimate of nursing workload	Subjective estimates of medication errors, nosocomial infections, patient falls, and incomplete nursing tasks	None
Byrne 1998[70]	Workload during simulated anesthesia cases	Recording errors on anesthetic charts of "patient's" oxygen saturation, heart rate, systolic & diastolic arterial pressures & end-tidal carbon dioxide concentrations	All subjects had the same simulated case.
Hunt 1998[63]	Nurse to patient ratio	In-hospital mortality and re-admission rates	None
Fridkin 1996[65]	Patient to nurse ratio in ICU	Bacteremia in patients with central venous catheter	APACHE-II

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 1. Nurse staffing (continued)

Author Year	Main Finding	Design Suitability/ Study Execution
Sochalski 2001[62]	Indirect association between workload estimates and measure of safety.	Least FAIR
Byrne 1998[70]	Chart recording errors increased with increased workload.	Least FAIR
Hunt 1998[63]	Lower ratio was associated with higher readmission rate but not with mortality.	Least FAIR
Fridkin 1996[65]	RN hours in ICU were 20.3/patient-day before outbreak of infections and 17.0 during the outbreak.	Least FAIR

ICU = intensive care unit; AIDS=acquired immuno deficiency syndrome; RN=registered nurse; ICD-9=international classification of diseases; ADL=activities of daily living; LVN=licensed vocational nurse; LPN=licensed practical nurse; CMS=Centers for Medicare and Medicaid Services; HCFA=Health Care Finance Administration; ER=emergency room; UTI=urinary tract infection; DVA=Department of Veterans Affairs

Evidence Table 2. Physician volume

Author Year	Study Question(s)	Design	Setting	Category of Health Professional	Working Condition
Nash 1999[79]	Does physician caseload affect inpatient mortality for acute MI?	Cross-sectional n=30,351 patients	1993 Pennsylvania hospital admissions for acute MI as initial episode of care	Cardiologists Internists Family Practitioners	Volume of cases per year by individual physician
Ellis 1997[81]	Does operator volume and experience influence the procedural outcome of percutaneous coronary revascularization?	Retrospective cohort n=12,985 patients Risk adjustment analysis	5 hospitals with high volume (>1,000 procedures per year) interventional cardiology programs in the US	38 physicians with ≥30 cases per year	Number of cases per year and years of experience
Margulies 2001[80]	Does case volume of trauma surgeons affect in-hospital mortality for severely injured patients?	Cross-sectional n=1754 patients	California	86 trauma surgeons in five Level I trauma centers	Case volume
Hartz 1999[44]	What is the relationship between training programs and experience and adjusted patient mortality rates?	Cross-sectional n= 83,547 patients	3 statewide databases (New York, Pennsylvania & Wisconsin)	275 cardiac surgeons	Physician experience and case volume
Czaplinski 1998[73]	Do physicians with three or more discharges per year for defined diagnoses experience lower patient mortality than lower volume physicians?	Cross-sectional n=11,316 patients	Single Connecticutt hospital	518 physicians	Total number of cases during study period

MI = myocardial infarction; ICD-9 = international classification of diseases; CCS = Canadian Cardiovascular Society; ACC/AHA = American College of Cardiology/American Heart Association

Evidence Table 2. Physician volume (continued)

Author Year	Measure of Safety	Casemix Control	Main Finding	Design Suitability/ Study Execution
Nash 1999[79]	In-hospital mortality	ICD-9 codes, severity of illness, age, gender, secondary logistic regression analysis to control for referral bias	Patients of physicians with higher caseloads for acute MI had lower mortality. Cardiologists had consistently higher caseloads than generalists.	Greatest FAIR
Ellis 1997[81]	In-hospital mortality, Q-wave infarction, emergency bypass surgery	Acute MI, age, CCS angina class, cardiogenic shock, left ventricular ejection fraction, modified ACC/AHA lesion classification score, number of diseased vessels, prior bypass surgery, prior restenosis, sex, unstable angina	High volume operators had a lower incidence of major complications. Years of experience were not associated with complication rates.	Greatest GOOD
Margulies 2001[80]	In-hospital mortality	Injury severity score, Glasgow coma scale, age, and type of injury	While institutional case volume was weakly related to survival rates, physician case volume was not.	Moderate POOR
Hartz 1999[44]	Mortality ratio	Predicted mortality rate based on patient characteristics	Physicians with highest case volumes had lowest mortality rates. Mortality rates increased with higher physician age and years of experience. Physicians trained at more prestigious programs or with current faculty appointments did not have lower mortality rates.	Moderate FAIR
Czaplinski 1998[73]	In-hospital mortality	Nursing unit on which patient was managed	There were no consistent mortality differences across the diagnostic groups between high volume and low volume physicians.	Moderate POOR

MI = myocardial infarction; ICD-9 = international classification of diseases; CCS = Canadian Cardiovascular Society; ACC/AHA = American College of Cardiology/American Heart Association

Evidence Table 3. Physician specialty

Author Year	Study Question(s)	Design
Latif 1998[84]	Do patients with malignant glioma have better outcomes if operated on by a surgical neuro-oncologist rather than a general neurosurgeon?	Cross-sectional n=236 patients
Gerbert 1996[85]	Do dermatologists have better sensitivity and specificity for recommending biopsy of skin lesions suspicious for cancer?	Cross-sectional 37 lesions on slides and computer images 25 lesions on patients
Fleischer 2001[86]	How does physician experience and specialty affect the quality of surgical excision of basal cell carcinoma?	Cross-sectional n= 1,459 specimens
Dorrance 2000[87]	Are patient outcomes after potentially curative colorectal cancer surgery different depending on the surgeon's specialty? What factors may help to explain differences in outcome among specialty groups?	Retrospective cohort n=378 for resections thought to be curative n=154 performed by colorectal surgeons n=126 performed by vascular/ transplant surgeons n=98 performed by general surgeons
Nash 1997[88]	Are outcomes for patients with acute myocardial infarction different when patients are cared for by a cardiology specialist versus a generalist?	Cross-sectional n=40,684 patients

ICD-9 = international classification of diseases

Evidence Table 3. Physician specialty (continued)

Author Year	Setting	Category of Health Professional	Working Condition	Measure of Safety
Latif 1998[84]	British university medical center	Surgical neuro-oncologist general neurosurgeons	Surgical specialty	30-day mortality, postoperative hematoma, and wound dehiscence
Gerbert 1996[85]	Dermatology clinic at a medical center in San Francisco, CA	71 primary care residents 15 dermatologists and resident dermatologists from San Francisco Bay area hospitals	Physician specialty	Correct recommendation of biopsy for skin lesions
Fleischer 2001[86]	4 US university medical centers	27 dermatologists 9 otolaryngologists 14 plastic surgeons 12 general surgeons	Physician experience and specialty	Tumor-free resection margins
Dorrance 2000[87]	A large university teaching hospital in Glasgow, UK	2 colorectal surgeons 6 vascular/ transplant surgeons 4 general surgeons	Surgeon specialty	Cancer recurrence rates
Nash 1997[88]	1993 Pennsylvania hospital admissions for acute myocardial infarction	Cardiologists, internists, family practitioners	Expertise (generalist/ specialist)	In-hospital mortality

ICD-9 = international classification of diseases

Evidence Table 3. Physician specialty (continued)

Author Year	Casemix Control	Main Finding
Latif 1998[84]	Tumor type, year of treatment and prognostic index	Post-operative complication rates were not significantly different between the group of patients operated on by the neuro-oncologist and the group operated on by general neurosurgeons.
Gerbert 1996[85]	Same cases for all participants	Dermatologists had sensitivity of .81 and specificity of .84 for recommending biopsy. Primary care residents had sensitivity of .67 and specificity of .73.
Fleischer 2001[86]	Sex, age, tumor characteristics	No significant difference was noted for physician experience. Otolaryngologists and plastic surgeons were more likely to incompletely excise tumors when compared to dermatologists. No difference was noted between dermatologists and general surgeons.
Dorrance 2000[87]	Information on demographic and operative details was collected and analyzed	Colorectal surgeons had lower local and overall cancer recurrence rates. Differences in local recurrence rates seem to be predominantly related to the extent of resection.
Nash 1997[88]	ICD-9 codes, severity of illness, age, gender	Patients cared for by cardiologists, as a group, had the lowest risk-adjusted mortality.

ICD-9 = international classification of diseases

Design Suitability/ Study Execution
Greatest FAIR
Greatest FAIR
Moderate FAIR
Moderate POOR
Moderate FAIR

Evidence Table 4. Staff experience

Author Year	Study Question(s)	Design
Blegen 2001[96]	What are the relationships between quality of patient care and the education and experience of the nurses providing that care?	Cross-sectional (Patient care units) n= 42 units in study 1 n= 39 units in study 2
Goodwin 2001[89]	What is the effect of surgical training for coronary artery bypass operations on patient mortality?	Cross-sectional n=2,740 patients
Nelson 2000[90]	What are the residents' understanding of drug dose calculations and ordering? What are the short term effects of a brief educational intervention on the skills required to properly calculate dosages and other medications?	Pre-test post-test
Hartz 1999[44]	What is the relationship between training programs and experience and adjusted patient mortality rates?	Cross-sectional n= 83,547 patients
Stevenson 1999[91]	Does adherence to training guidelines for pediatric TEE affect the outcome of patients undergoing repair of congenital cardiac defects?	Retrospective cohort n= 219 patients

TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human immunodefi
ACLS = advanced cardiac life support

Setting
Acute-care hospitals 1 large tertiary-care hospital in study 1, 11 hospitals in study 2
Regional cardiothoracic surgery unit in Cambridge, UK
Urban public hospital in New York, NY
3 statewide databases (New York, Pennsylvania & Wisconsin)
Children's hospital in Seattle, WA

iciency virus;

Evidence Table 4. Staff experience (continued)

Author Year	Category of Health Professional	Working Condition	Measure of Safety
Blegen 2001[96]	Nurses	Education and experience	Medication errors and patient fall rates
Goodwin 2001[89]	Senior and trainee surgeons	Physician composition of surgical team	30 day mortality, post-operative bleeding and wound infections
Nelson 2000[90]	30 emergency medical residents 20=intervention 10=controls	Training	Drug dosing errors in simulated cases
Hartz 1999[44]	275 cardiac surgeons	Physician experience and case volume	Mortality ratio
Stevenson 1999[91]	8 Physicians	Training qualification	Diagnoses and hospital deaths

TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human immunodeficiency virus; ACLS = advanced cardiac life support

Evidence Table 4. Staff experience (continued)

Author Year	Casemix Control	Main Finding	Design Suitability/ Study Execution
Blegen 2001[96]	Patient acuity, hours of nursing care, staff mix	Units with more experienced nurses had lower medication errors and lower patient fall rates. Units with more baccalaureate-prepared nurses were not significantly better.	Moderate FAIR
Goodwin 2001[89]	Parsonnet score	Patients operated on by teams comprised of trainees and senior surgeons had the same complication rates as patients operated on by senior surgeons.	Moderate FAIR
Nelson 2000[90]	Same questions administered to all. Repeat test had similar format.	Training in calculating and executing drug ordering is required. A brief educational intervention significantly improved short-term performance.	Moderate FAIR
Hartz 1999[44]	Predicted mortality rate based on patient characteristics	Physicians with the highest case volumes had the lowest mortality rates. Mortality rates increased with higher physician age and years of experience. Physicians who had trained at more prestigious programs or had current faculty appointments did not have lower mortality rates.	Moderate FAIR
Stevenson 1999[91]	None	Adherence to training guidelines for pediatric TEE favorably affects patient outcomes.	Moderate POOR

TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human immunodeficiency virus; ACLS = advanced cardiac life support

Evidence Table 4. Staff experience (continued)

Author Year	Study Question(s)	Design
Pollack 1997[92]	What impact do pediatric critical care training programs have on pediatric intensive care mortality?	Cross-sectional n= 2,744 admissions (fellowship program) n= 3,006 (non-fellowship program)
Eldar 1996[93]	How do residents compare to qualified surgeons in the performance of laparoscopic cholecystectomies?	Cross-sectional n=137 operations and n=76 operations
Paauw 1995[94]	What is the ability of primary care physicians to recognize physical findings associated with HIV infection?	Cross-sectional n= up to 3 cases presented
Birnbaum 1994[97]	Does ACLS training affect the process and quality of care to patients with ischemic heart disease?	Pre-test post-test n= 869 patients
Pollack 1994[95]	How do ICU size, medical school teaching status and specialist status affect pediatric ICU mortality?	Cross-sectional n= 5,415 admissions

n = number; TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human
ACLS = advanced cardiac life support

Setting
16 pediatric ICUs in the U.S. 8 with critical care fellowships
Medical center in Israel
University clinic Seattle, WA
7 rural, community hospitals in Wisconsin
16 pediatric ICUs in the U.S.

immunodeficiency virus;

Evidence Table 4. Staff experience (continued)

Author Year	Category of Health Professional	Working Condition	Measure of Safety
Pollack 1997[92]	Physicians-fellows, residents	Training	Adjusted mortality rate
Eldar 1996[93]	5 staff surgeons 3 staff/resident surgeon teams	Training	Post-operative infections and other immediate complications
Paauw 1995[94]	134 general internists and family practitioners	Subjective report of physician experience with HIV patients	Correct diagnosis
Birnbaum 1994[97]	69 Physicians 277 Nurses 115 Other critical care staff	Training	In-hospital deaths
Pollack 1994[95]	Pediatric intensivists, residents	Provider specialty training	Adjusted mortality

n = number; TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human immunodeficien
ACLS = advanced cardiac life support

Evidence Table 4. Staff experience (continued)

Author Year	Casemix Control	Main Finding	Design Suitability/ Study Execution
Pollack 1997[92]	Severity, diagnosis	Overall, adjusted mortality rates were lower in pediatric ICUs located in hospitals having critical care fellowship programs.	Moderate FAIR
Eldar 1996[93]	Demographic and clinical characteristics were compared.	Complication rates were no higher in cases performed by residents supervised by attending surgeons than in cases performed by attending surgeons.	Moderate FAIR
Paauw 1995[94]	Standardized patients	The majority of physicians did not detect the physical condition and provide correct diagnoses. Experience with HIV infection was associated with identification of oral hairy leukoplakia.	Moderate FAIR
Birnbaum 1994[97]	Disease severity score	ACLS training benefits the ACLS program and patient survival.	Moderate GOOD
Pollack 1994[95]	Physiologic status, diagnosis and other mortality risk factors	Medical school teaching status was related to higher mortality and specialist status was related to lower mortality. Residents may explain the higher mortality seen in teaching hospitals. No significant associations were noted for ICU size.	Moderate FAIR

n = number; TEE = transesophageal echocardiography; ICU = intensive care unit; HIV = human immunodeficiency virus; ACLS = advanced cardiac life support

Evidence Table 5. Temporal factors

Author Year	Study Question(s)	Design	Setting
Rosa 1993[102]	Is performance poorer on a 12-hour work shift than on an 8-hour shift for utility workers?	Time-series study of change in work schedule	Natural gas utility
Bell 2001[103]	Is in-hospital mortality higher among patients admitted on weekends?	Retrospective cohort of 3.8 million acute care patients admitted from ERs	All hospitals in Ontario, Canada
Bollschweller 2001[104]	Is length of work-shift for physicians associated with patient complications?	Cross-sectional study comparing 8-hour and 12-hour physician shifts	Six German ICUs
Booker 1995[105]	Are medication error rates related to season or photoperiod?	Time series analysis	Alaskan acute care hospital
Gold 1992[106]	Is the shift assignment of nurses associated with incidence of medication errors?	Survey of 635 nurses	US hospital
Novak 1988[107]	Is the shift assignment of factory workers associated with rates of on-the-job injuries?	Time series analysis	Chemical factory
Smith 1995[108]	Do night-shift workers perform poorer than day-shift workers?	Cross-sectional	22 shiftworkers in one nuclear power plant
Palinkas 1986[109]	Is service in an isolated cold environment associated with poorer job performance?	Case-control	Navy personnel serving in Antarctica and control personnel
Northrup 1979[110]	Is implementation of 12-hour work shifts associated with reduced work efficiency or increased workplace injuries?	Survey of managers	Chemical and petroleum plants

ER = emergency room; ICU = intensive care unit; LPN = licensed practical nurse; N/A = not applicable

Evidence Table 5. Temporal factors (continued)

Author Year	Category of Health Professional	Working Condition	Measure of Safety
Rosa 1993[102]	Non-medical	Length of work shift	Computerized battery of cognitive and motor skills
Bell 2001[103]	N/A	Day of week that patient received initial care	In-hospital mortality
Bollschweller 2001[104]	ICU physicians	8-hour vs. 12-hour work-shift	Hospital-acquired infections and adverse drug reactions
Booker 1995[105]	Nursing staff	Length of day time of year	Medication errors
Gold 1992[106]	RNs and LPNs	Shift assignment	Recalled medication errors
Novak 1988[107]	Non-medical	Rotating shifts vs. fixed shifts	Workplace injuries
Smith 1995[108]	Non-medical	Day-shift vs. night-shift	Cognitive function and alertness
Palinkas 1986[109]	Non-medical	Service in isolated extreme environment	Desertions, demotions, and absences
Northrup 1979[110]	Non-medical	8-hour vs. 12-hour shifts	Estimated productivity and workplace injuries

ER = emergency room; ICU = intensive care unit; LPN = licensed practical nurse; N/A = not applicable

Evidence Table 5. Temporal factors (continued)

Author Year	Casemix Control	Main Finding	Design Suitability/ Study Execution
Rosa 1993[102]	Some workers served as their own controls	Workers on 12-hour shifts had poorer performance especially at night.	Greatest FAIR
Bell 2001[103]	Age, sex, Charlson Comorbidity Index	Mortality rates were higher for weekend admissions for several diagnoses.	Moderate FAIR
Bollschweller 2001[104]	APACHE-II	Complication rates were not significantly different between ICU's with 8-hour shifts and ICU's with 12-hour shifts.	Moderate FAIR
Booker 1995[105]	Nursing workload	Medication errors greatest 1-2 months after darkest month, after controlling for medication error increase with increased temporary worker shifts and patient days per month, and decrease with increased overtime per month.	Moderate GOOD
Gold 1992[106]	None	Reported medication errors were slightly higher among nurses who rotated among shifts than among nurses who worked the same shift compared to day or evening shift nurses. Night shift nurses reported more near misses but similar rates of medication errors.	Moderate FAIR
Novak 1988[107]	Gender	Workers on rotating shifts had higher injury rates.	Moderate FAIR
Smith 1995[108]	None	Performance was poorer among night-shift workers.	Least FAIR
Palinkas 1986[109]	Demographic factors	No difference in rates of adverse outcomes between groups, but all rates were low.	Least FAIR
Northrup 1979[110]	None	No reported increase in accidents or decreased operational efficiency.	Least FAIR

ER = emergency room; ICU = intensive care unit; LPN = licensed practical nurse; N/A = not applicable

Evidence Table 6. Interruptions

Author Year	Study Question(s)	Design Population Setting
Flynn 1999[112]	Are workplace interruptions associated with medication dispensing errors?	Observational Task analysis of 14 pharmacists and 10 pharmacy technicians at an ambulatory care pharmacy. General medical surgical hospital Alabama
Pape 2002[134]	Is inpatient nurse use of a protocol to reduce distractions during medication dispensing effective?	Quasi-experimental Comparison of distractions during medication dispensing in 2 intervention and 1 control group. 17 licensed and registered nurses during 24 medication dispersing cycles. Medical-surgical nursing unit 520 bed hospital Southeast Texas
Peterson 1999[131]	1) Do pharmacists believe the risk of dispensing errors and number of errors are increasing? 2) What are the major factors contributing to dispensing errors? 3) What factors can minimize dispensing errors?	Observational Cross-sectional survey Mailed to 419 registered pharmacists Tasmania, Australia

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not s

Working Condition

Interruption - cessation of activity due to externally imposed reason.
Distraction - observable response to externally imposed reason (short of activity cessation).

Interruptions
Distractions

Interruptions
Workload
Noise
Packaging/
labeling

significant

Evidence Table 6. Interruptions (continued)

Author Year	Outcomes	Data Collection		Analysis
		Tools	Measures	
Flynn 1999[112]	Association between GEFT scores, interruptions/ distractions and medication dispensing errors	GEFT scores, work process videotapes	Interruptions, distractions workload; dispensing errors and types	Analysis of covariance using square root transformation of the number of errors (dependent variable) and interruptions/distractions (independent variables).
Pape 2002[134]	Distractions	Demographic data form Medication Administration Distraction Observation Sheet	Demographics Nursing education and experience Distractions (total and by type)	Descriptive frequencies One way ANOVA Multiple and bivariate linear progression.
Peterson 1999[131]	Trend in dispensing errors Factors contributing to errors Factors minimizing errors	Survey	Response to survey questions, some with visual analogue scale	Frequency of responses Comparison of pharmacy owners/non-owners. Correlation between years as pharmacist and response.

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not significant

Evidence Table 6. Interruptions (continued)

Author Year	Results	Design Suitability/ Study Execution
Flynn 1999[112]	164 dispensing errors in 5072 prescriptions (3.2% rate, CI 3.1-3.4). Wrong label error (80%) most common 2022 interruptions during 1143 prescriptions 6.65% errors in interrupted prescriptions 5.67% in uninterrupted prescriptions Errors increase with interruptions per half hour (p=.004) GEFT associated with error rate (p=0.03) Relationship between interruptions and errors NS when GEFT score used as co-variate.	Greatest GOOD
Pape 2002[134]	Significant reduction in distractions during medication administration for: focused protocol (180 distractions p=.014) Medsafe © protocol (64 distractions, p=.000) when compared to control cycles (484 distractions) Conversation, other personnel interrupting and external noise contributed most to distraction.	Moderate FAIR
Peterson 1999[131]	50% response rate 82% felt *risk* of errors increasing 47% felt *actual* errors increasing Major factors for errors rated as: a) high dispensing volume (84%) b) pharmacist overwork (80%) c) fatigue (80%) d) interruptions to dispensing (76%) e) confusing or similar drug names (75%) Owners rated interruptions as less important than non-owners- (70% as compared to 80%).	Least FAIR

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not significant

Evidence Table 6. Interruptions (continued)

Author Year	Study Question(s)	Design Population Setting
Ely 1995[133]	What are family physician's most memorable errors and their perceived causes?	Observational-Cross-sectional interviews. Random sample of 53 consenting family physicians selected from all practicing physicians. Eastern Iowa
Gladstone 1995[132]	What are the most common risk factors for nurses in the process of drug administration?	Observational-retrospective analysis. 79 drug error accident reports 102 nurses 17 nurse managers District general hospital in Southwest England.
Cooper 1984[121]	What are the types of failures, nature of the activities during failure, and associated factors in errors and equipment failures in anesthesia?	Observational-Critical incident analysis-Retrospective structured interviews and "instant" voluntary reports. ***Phase 1:*** 48 anesthesiologists 30 residents 13 nurse anesthetists 2 teaching and 2 community hospitals Boston metro area ***Phase 2:*** 18 anesthesiologists 21 residents 9 nurse anesthetists Teaching hospital Boston metro area

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not s

Working Condition

Distractions - preoccupation with other activities/obligations

Interruptions and distractions

Distraction by 1 task to the exclusion of others.
Visual restriction
Lack of sleep/fatigue
Supervisor not present enough.
Inadequate supervision
Conflicting equipment designs.

significant

Evidence Table 6. Interruptions (continued)

Author Year	Outcomes	Data Collection		Analysis
		Tools	Measures	
Ely 1995[133]	Categorize recalled errors and perceived causes	Audiotapes and transcripts of a focus group and in-depth interviews	1) Demographic characteristics of participants and non-participants 2) Classification of errors from focus group 3) Causes of error rated on 4 point scale	Descriptive statistics
Gladstone 1995[132]	Ranking of causes of drug error and factors contributing to error	Drug error accident reports. Interviews with nurses reporting errors. Questionnaires to dispensing and managing nurses.	Type of drug error, route of administration, time of day, type of follow-up intervention, ranking of causes of error, nurses' feelings and manager reaction, factors contributing to error	Descriptive frequencies
Cooper 1984[121]	Distribution of critical incidents by type and nature of failure, by nature of activity, by type of equipment involved, and associated factors cited	***Phase 1:*** Taped interviews, summary transcripts ***Phase 2:*** Taped interviews, summary transcripts, voluntary reporting forms	Data coded in content domains, fields on reporting form	Characteristics categorized by two investigator consensus, extracted and summary frequencies provided

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not significant

Evidence Table 6. Interruptions (continued)

Author Year	Results	Design Suitability/ Study Execution
Ely 1995[133]	53/70 (76%) agreed to interview: 53 errors 30 delayed or missed diagnoses 11 surgical mishaps 8 medical treatment mishaps Causes included 48 (91%) of cases - physician stressors 48 (91%) of cases - process-of- care factors 38 (72%) of cases - patient-related factors 33 (62%) of cases - physician characteristics 25 (47%) of cases - physician felt “distracted”	Least FAIR
Gladstone 1995[132]	Dose-related Highest ranked causes: 1) failure to check patient identification 2) prescription illegible 3) nurse distracted 4) miscalculation of dose 5) infusion device set up or adjustment incorrect The most frequent risk factors cited by nurses were interruptions, workload, skill mix and loss of concentration.	Least FAIR
Cooper 1984[121]	855 critical incidents 616 retrospective 239 “instant” reporting: 115 (13%) equipment failure 583 (68%) human error 111 (13%) disconnect 46 (5%) other 71 incidents reported "other distractive simultaneous anesthesia activities” as an associated factor 83 visual restriction 55 lack of sleep/fatigue 52 supervisor not present enough 34 inadequate supervisor 34 conflicting equipment designs	Least FAIR

GEFT = group embedded figures test (for distractibility); CI = confidence interval; NS = not significant

Evidence Table 7. Transitions

Author Year	Study Question(s)	Design Population Setting
Naylor 1999[141]	Does a discharge and 4-week home follow-up protocol implemented by advanced practice nurses affect longer term hospital readmissions?	RCT 363 patients age ≥ 65 (mean 75) with medical or surgical diagnoses admitted from home and at high risk for poor discharge outcomes. 2 Philadelphia hospitals
Diem 1996[143]	What is the effect of an admitting resident discharge clinic on house staff education and utilization of hospital services?	RCT 751 patients discharged to home Denver VA medical center
Siu 1996[165]	Does a nurse practitioner intervention begun during hospitalization and continued for 3 visits after discharge improve survival and reduce hospital readmissions & nursing home placement among frail elders?	RCT 354 patients age > 65 discharged Los Angeles academic medical center
Weinberger 1996[159]	Does increasing post discharge access to primary care reduce readmissions and hospital days?	RCT 1396 chronically ill patients from 9 VA medical centers. Throughout US

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 7. Transitions (continued)

Author Year	Intervention
Naylor 1999[141]	Discharge planning and 4-week home follow-up protocol implemented by advanced practice nurses
Diem 1996[143]	Discharge clinic within 10 days of discharge
Siu 1996[165]	Nurse practitioner assessment prior to discharge Geriatrics team consultation with recommendations to primary physician 3 follow-up home visits
Weinberger 1996[159]	Nurse and primary care physician assessment/counseling before discharge, nurse call 2nd day post discharge, post discharge appointment at 1 week, phone access (average nurse calls 7.5 in 6 mos.)

RCT = randomized controlled trial; VA = Veterans Administration; mo
non-significant; ER = emergency room; QWB = quality of well-being;
activities of daily living

Outcome
Hospital readmission Time to first readmission
Hospital days Hospital readmissions within 30 days ER visits Deaths
Deaths Readmissions Nursing home placement SF-36;(QWB) Satisfaction Medication adherence, number of medications
Hospital readmission Hospital days

ɔs = months; I = intervention; C = control; NS =
wks = weeks; hrs = hours; ADL =

Evidence Table 7. Transitions (continued)

Author Year	Results	Design Suitability/ Study Execution
Naylor 1999[141]	Readmission rate at 24 weeks: I: 36 (20.3%); C: 69 (37.1%) p=<.01. Time to readmission lower in I than C (p<.001 discharge to 6 weeks, p=.02 6 to 24 weeks). No difference between I & C in functional status, depression, and patient satisfaction.	Greatest GOOD
Diem 1996[143]	Readmissions in 30 days: NS Mean length of stay: NS 14 (10%) medication errors noted at discharge clinic 5 (3.5%) tests not scheduled as expected. I group had fewer ER visits than C group (65 [20.8%] vs 123 [28%]; p=.03). Deaths: NS	Greatest FAIR
Siu 1996[165]	*At 60 days:* Deaths: NS: 7 (4%) I vs. 8 (4.5%) C Readmissions: NS: 43 (24%) I vs. 37 (21%) C Nursing home placement: NS: 7 (4%) I vs. 6 (3.4%) C SF-36; QWB NS. I group less satisfied at 30 days (p=.02). Medication use NS.	Greatest GOOD
Weinberger 1996[159]	I group higher monthly readmission than C group (0.19 vs 0.14, p=0.005) and more rehospitalization days (10.2 vs 8.8, p=0.04). I group more visits to medicine clinic (3.7 vs 2.2, p<0.001). Quality of life NS at 1 & 6 mos. I group more satisfied (p<0.001).	Greatest GOOD

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 7. Transitions (continued)

Author Year	Study Question(s)	Design Population Setting
Martin 1994[161]	Does a hospital discharge team for the elderly with 6 weeks of support after discharge reduce hospital readmissions and length of hospital stay?	RCT 54 patients mean age 82 UK hospital and community
Naylor 1994[164]	Does a discharge and home follow-up protocol implemented by nurse specialists with 2 weeks follow-up affect patient and caregiver outcomes?	RCT 276 patients age 70+ with 125 caregivers Admitted to the Hospital of the University of Pennsylvania from home with medical or surgical cardiac diagnoses
Hansen 1992[163]	What is the effect of home visits on the elderly after discharge from the hospital?	RCT 344 patients ≥75 Roskilde, Denmark county hospital
Lipton 1992[162]	Does clinical pharmacist consultation to geriatric patients and their physicians before and after hospital discharge reduce clinically significant drug problems?	RCT 236 patients ≥65 discharged on 3 or more medications Community nonteaching hospital in San Francisco Bay area

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 7. Transitions (continued)

Author Year	Intervention
Martin 1994[161]	Ward team nurse manager assessment Nurse manager supervising health care assistants who visited up to 3 times a day for 6 weeks
Naylor 1994[164]	Discharge planning and home protocol implemented by nurse specialists from admission to 2 weeks past discharge
Hansen 1992[163]	Home visit by district nurse 1 day after discharge General practitioner home visit 15 days after discharge
Lipton 1992[162]	Patient books to record medication; medical record review; pharmacist consultation to patient and physician at and for 3 months post discharge

RCT = randomized controlled trial; VA = Veterans Administration; mo
non-significant; ER = emergency room; QWB = quality of well-being;
activities of daily living

Outcome
Place of residence
Hospital readmission
Number of hospital days
Mental test, morale, self-care & domestic ability
Length of stay
Time from discharge to readmission
Hospital readmission
1 year after discharge:
Hospital readmissions
Nursing home admissions
Deaths
Institutional days
Prescribing problems
Appropriateness of prescribing

ɔs = months; I = intervention; C = control; NS =
wks = weeks; hrs = hours; ADL =

Evidence Table 7. Transitions (continued)

Author Year	Results	Design Suitability/ Study Execution
Martin 1994[161]	*At six weeks:* Living at home 24 (83%) I vs. 10 (40%) C (p=<0.001). Readmissions 4 (14%) I vs. 9 (38%) C (p=<0.01). Living at home still significant 12 weeks and 1 year. Readmissions: 12 weeks NS Alive not readmitted 12 I vs. 4 C; p= <0.05 for 1 year. Inpatient days lower I vs.C at 12 weeks (p=0.05) but not one year. No difference mental test.	Greatest FAIR
Naylor 1994[164]	Time from discharge to readmission: NS Medical group: a) Readmissions at 2 wks: I: 3 (4%); C: 11 (16%) p=0.02; at 2-6 wks and for 12 wks: NS b) Days rehospitalized in I less than C at 2 wks (p=.002) & 2-6 wks (p=.01). Surgical group: NS outcome differences I vs C	Greatest GOOD
Hansen 1992[163]	Readmissions: NS Nursing home admissions: 16 (9.8%) I vs. 29 (16%) C; p=<0.05 Deaths: 32 (20%) I vs. 43 (24%) C; NS Group total institutional days: 1950 I vs. 2700 C	Greatest GOOD
Lipton 1992[162]	88% patients clinically significant drug problem; 22% patients had potentially injurious or life threatening drug problem. 103/123 (84%) I vs. 103/113 (92%) C with at least 1 prescribing problem (p=0.05); percent less than optimal medication & wrong dosage lower in I than C (p=0.01; p=0.05). Overall appropriateness of prescribing score .59 I, .76 C (p=0.01).	Greatest GOOD

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 7. Transitions (continued)

Author Year	Study Question(s)	Design Population Setting
Smith 1988[158]	Does an intention to increase post discharge ambulatory contacts reduce non-elective readmissions?	RCT 1001 patients average age 52 consecutively discharged from general medicine service with chronic disease University-affiliated hospital in Indianapolis
Townsend 1988[160]	How does use of a care attendant after hospital discharge compare with standard aftercare for effects on independence, morale and use of services?	RCT 903 patients aged >75 with chronic disease District general hospital & Harrow community, UK hospital discharged to home

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 7. Transitions (continued)

Author Year	Intervention
Smith 1988[158]	Outpatient clinic team nurse phone call to patient 1 week post discharge, contact at clinic visit, mailing post discharge to patient
Townsend 1988[160]	Care attendant visit before discharge, first day home and up to 12 hrs/wk for 2 weeks

RCT = randomized controlled trial; VA = Veterans Administration; mo
non-significant; ER = emergency room; QWB = quality of well-being;
activities of daily living

Outcome
Non-elective hospital admission
Physical independence through ADL
Morale (Philadelphia Geriatric Morale Scale)
Hospital readmissions
Deaths

ɔs = months; I = intervention; C = control; NS =
wks = weeks; hrs = hours; ADL =

Evidence Table 7. Transitions (continued)

Author Year	Results	Design Suitability/ Study Execution
Smith 1988[158]	Non-elective admissions: NS I: .104/patient/month; C: .103/patient/month p=0.4 Readmission days: NS I: 7.6% less than C (NS, p=0.5) High risk: (31.9% fewer hospital days/patient/month):NS I: 1.13 hospital days/patient/month C: 1.66 hospital days/patient/month p=0.06 Clinic contact increased in intervention: I: .53/patient/month; C: .48/patient/month p=.005	Greatest GOOD
Townsend 1988[160]	No significant change in independence or morale. No significant difference in deaths: I: 34 (7%); C: 25 (6%) Difference in total readmissions: NS at 3 months: I: 105 (23%); C: 102 (23%) Significant at 18 months for more than 2 readmissions: I: 23 (6.7%); C: 43 (13.9%) Days in hospital at 18 months: I: 18.2; C: 22.8	Greatest GOOD

RCT = randomized controlled trial; VA = Veterans Administration; mos = months; I = intervention; C = control; NS = non-significant; ER = emergency room; QWB = quality of well-being; wks = weeks; hrs = hours; ADL = activities of daily living

Evidence Table 8. Stress

Author Year	Study Question(s)	Design/ Population/ Setting
Is stress associated with errors?		
Dugan 1996[194]	Is stress associated with rates of patient incidents or staff turnover?	Cross-sectional Midwest US acute care hospital 293 of 600 nursing staff on 19 units. Response rate 49%.
Jones study 1 1988[195]	Do hospital departments with high malpractice rates have high department-average stress scores?	Cross-sectional 91 departments in five small to medium sized general care hospitals across US. Clinical and non-clinical department staff.
Jones study 2 1988[195]	Do hospitals with high reported levels of workplace and personal stress have higher rates of malpractice claims?	Cross-sectional 61 Midwestern hospitals
Does a stress management intervention reduce errors?		
Jones study 4 1988[195]	Is malpractice risk reduced in hospitals employing a hospital-wide stress management program, compared to matched control hospitals?	Pre-test/Post-test with control group
Jones study 3 1988[195]	Does a hospital wide stress management program reduce the incidence of medication errors?	Time series study of a single US hospital; 676 of 700 employees

IV = intravenous

Evidence Table 8. Stress (continued)

Author Year	Working Condition	Measure of Safety	Other respondent characteristics measured
Dugan 1996[194]	Burnout and self-rated stress symptom score; stress continuum scale	Patient incidents (medication errors, IV errors, falls)	Nurse injuries (back injuries, needle sticks)
Jones study 1 1988[195]	Job stress, organizational stress	Malpractice claim records, error and negligence identified by hospital administrative staff	Personal stress, job dissatisfaction
Jones study 2 1988[195]	Job stress, organizational stress	Malpractice claims history	Personal stress, job dissatisfaction hospital size
Jones study 4 1988[195]	Stress management program	Malpractice claims data one year before and one year after program implementation	Hospital size, location, and malpractice claims history
Jones study 3 1988[195]	Stress management program	Monthly medication error data from incident report system for 8 months prior and 7 months after intervention	

IV = intravenous

Evidence Table 8. Stress (continued)

Author Year	Main Finding	Design Suitability/ Study Execution
Dugan 1996[194]	Patient incident rates were correlated with average perceived nursing unit stress (R=0.43,p=0.05) but not with average reported stress symptoms (R-0.23, p=0.10). Nurse turnover was not correlated with perceived stress or reported stress symptoms.	Least FAIR
Jones study 1 1988[195]	Departments with higher malpractice risk had higher job stress, organizational stress, and job dissatisfaction. Personal stress not significantly different.	Least FAIR
Jones study 2 1988[195]	Job stress, organizational stress and hospital size were correlated with hospital malpractice risk; job dissatisfaction and personal stress were not.	Least FAIR
Jones study 4 1988[195]	Malpractice claims rate was significantly lower following intervention; no reduction in control hospitals.	Greatest FAIR
Jones study 3 1988[195]	Medication error rates were significantly less frequent following establishment of the stress management program.	Least FAIR

IV = intravenous

Evidence Table 9. Job satisfaction

Author Year	Study question(s)	Design/ Population/ Setting
DeVoe 2002[197]	Is career dissatisfaction associated with family physicians' ability to provide high quality patient care?	Survey of 3,166 US family physicians (~65% response rate)
Shanafelt 2002[199]	Are suboptimal patient care practices reported more frequently by physicians reporting symptoms of burnout?	Survey Multi-hospital program in NW US 115/151 internal medicine residents
Bond 2001[196]	Is the risk of pharmacist medication error related to workplace, workload, and pharmacist satisfaction?	Survey of 2,437/7,298 Texas pharmacists; response rate 33%.
Carey 2001[189]	Do relationships exist between collectivism, error orientation, and workload, control, and monotony among nurses?	Survey of 209/702 RNs in 11 US cities; response rate 30%.
Firth-Cozens 1997[198]	What factors lead to stress that impacts patient care?	Qualitative study open-ended questions included in survey of 82 British physicians who reported incidents of adverse care. 302 questionnaires sent out, 225 returned, 82 responses used.
Leppa 1996[200]	Are interpersonal relationships related to job satisfaction? Is satisfaction with relationships related to workgroup disruption? Is workgroup disruption related to quality and safety of patient care?	Survey of 908 RNs in 4 US tertiary care hospitals. Response rates in each hospital ranged from 61% to 75%.

RN = registered nurse

Evidence Table 9. Job satisfaction (continued)

Author Year	Working condition	Measure of safety	Other respondent characteristics measured
DeVoe 2002[197]	Career satisfaction	Subjective assessment of ability to provide quality patient care	Personal, professional, practice characteristics
Shanafelt 2002[199]	Stressors including sleep, shift length, leisure time; burnout (Maslach Burnout Inventory)	Suboptimal patient care practices; suboptimal patient care attitudes	Self-reported depression and substance use
Bond 2001[196]	Workload and workflow variables, worksite type, satisfaction with practice	Subjective estimate of rate of medication errors.	Demographic variables
Carey 2001[189]	Workload, Job Control, Monotony, Collectivism and Autonomy; nursing work type	Error Orientation, including subscales of error competency, risk taking, communication, learning from and covering up error	
Firth-Cozens 1997[198]	Tiredness, overwork pressure, anxiety/depression, alcohol, boredom	Irritability/anger, lowered standard of care, serious nonfatal mistakes, patient death	Coping, work attitudes, career choice, alcohol use
Leppa 1996[200]	Work group cohesion (satisfaction with relationships, workgroup disruption)	2 items on perceived quality of care	12 month data on absenteeism, agency use, personnel flux, controlled for unit size

RN = registered nurse

Evidence Table 9. Job satisfaction (continued)

Author Year	Main finding	Design suitability/ Study execution
DeVoe 2002[197]	18% were dissatisfied with career in medicine. Inability to provide quality care to patients was associated with higher dissatisfaction.	Least FAIR
Shanafelt 2002[199]	76% of residents had burnout and reported more frequent suboptimal patient care practices (errors in medication or treatment or discharge of patients to reduce team workload). Stressors were: inadequate sleep (41%) frequent shifts of over 24 hrs (42%) insufficient leisure time (42%) Coping strategies were: talking with family (72%) other residents (75%) Program features helpful for stress were: at least four days off/month (97%) ancillary help (95%) night float call system (64%)	Least FAIR
Bond 2001[196]	Higher dispensing error risk was associated with lower pharmacist satisfaction, higher workload, and lower professional involvement.	Least FAIR
Carey 2001[189]	Collectivism score was associated with error communication.	Least GOOD
Firth-Cozens 1997[198]	Causes most often cited: tiredness (57.4%) pressure from overwork (27.7%) Most common consequences cited: lowered standard of care (50%) irritability/anger (40.2%) 2 deaths and 6 serious mistakes were reported.	Least GOOD
Leppa 1996[200]	Absenteeism and agency use were associated w/ lower satisfaction; quality of nursing interaction was associated with perceived quality and safety of care; agency use was associated with lower perceived quality and safety of care.	Least FAIR

RN = registered nurse

Evidence Table 10. Physical environment

Author Year	Study Question(s)	Design/ Population/ Setting
Flynn 1996[213]	What is the association between ambient sounds and pharmacists' prescription filling errors in a pharmacy?	Case-control comparison of prescriptions with dispensing errors to prescriptions by the same pharmacist without errors. Sample of cases was selected from a prospective study of prescription dispensing errors. 13 licensed pharmacists, age 26-51, hearing test within normal range, working in 451 bed, not-for-profit medical center
Walsh-Sukys 2001[216]	Do physical modifications to reduce light and sound levels in a neonatal intensive care unit affect patient safety?	Cross-sectional comparison of one remodeled unit and one traditional unit in a single hospital 126 patient admissions
Knez 1998[217]	What are the effects of office lighting on mood and cognitive performance?	Randomized trial of two different lighting conditions for performing cognitive tasks n=80; 40 males, 40 females; age 18-55 Volunteer subjects
Stone 1998[218]	What is the impact of windows on worker performance?	Randomized trial comparing cognitive tasks in rooms with or without windows Undergraduate students, Midwestern University n=120
Kwallek 1997[219]	What is the impact of three different color schemes on worker performance?	Non-random comparison of office tasks between groups of office workers matched for office skills and demographic factors 3 different colored office spaces the same size: 8ft. 8in. wide, 11ft. 6.5in. long, 8ft. high
Kwallek 1996[220]	What is the effect of interior office colors on clerical tasks?	Randomized trial comparing clerical task performance in nine differently colored offices 675 students; 341 males, 334 females; age16-37; color-blinded students excluded

Evidence Table 10. Physical environment (continued)

Author Year	Outcomes	Results	Design Suitability/ Study Execution
Flynn 1996[213]	Uncontrolled and controlled sound; predictable and unpredictable sound; noise; loudness	31 cases of prescription errors were compared to 31 error-free cases by the same pharmacist. Ambient sound levels were not associated with error occurrence.	Greatest FAIR
Walsh-Sukys 2001[216]	Measures of patient safety included medication errors, unplanned extubations, IV infiltrations, nosocomial infections, and mortality. No casemix controls.	Lighting and sound levels were significantly lower in the remodeled unit, but there were no differences in any of the measures of patient safety.	Moderate GOOD
Knez 1998[217]	Cognitive performance: 3 memory tasks, 1 problem-solving task, 1 judgment task	No effect of lighting on cognitive performance.	Moderate FAIR
Stone 1998[218]	Performance: filing, computational, or creative task	Windows did not have an effect on performance.	Moderate FAIR
Kwallek 1997[219]	Performance: Minnesota Clerical Test: number comparison task, names comparison tasks	No difference for color schemes alone. Individual differences accounted for differences in impact of color scheme on performance.	Moderate FAIR
Kwallek 1996[220]	Human performance: Minnesota Clerical Test measures speed and accuracy of clerical tasks	There were significantly more proofreading errors in white offices vs. red or blue offices.	Moderate FAIR

Evidence Table 10. Physical environment (continued)

Author Year	Study Question	Design/ Population/ Setting
Ainsworth 1993[221]	What is the effect of office color on performance?	Randomized trial of typing performance in three office colors 45 female college students Single office space, 15 ft. by 10 ft., 11 ft. ceiling
Stone 1993[222]	What is the impact of windows on worker performance?	Randomized trial of simulated office and managerial rooms with or without windows Undergraduate students, Creighton University n=40
Buchanan 1991[223]	Does illumination level affect dispensing errors in a high-volume outpatient pharmacy?	Time-series analysis of cohort of five pharmacists working in outpatient pharmacy in which lighting levels were changed on successive days.
Rosenberg 1989[224]	What is the impact of window shape and reticle presence on performance?	Within-subjects comparison in a simulated space station 20 volunteers, screened for vision acuity
Noweir 1984[225]	What is the effect of noise exposure on industrial accidents?	Cross-sectional comparison of textile workers exposed to varying noise levels n=2,458 male workers Textile mills
Kwallek 1988[226]	What is the effect of a red vs. a blue office environment on clerical tasks?	Non-randomized comparison of typing skills between groups assigned to four different sequences of office colors 36 paid subjects, matched on age and typing ability Simulated office spaces, 8 ft. wide, 11 ft., 9 in. long, 8 ft. 9 in. high, blue or red color
Enander 1987[227]	What is the effect of moderate cold exposure on psychomotor and cognitive tasks?	Time-series comparing cognitive and motor tasks in two temperatures (5.5 degrees celcius and 21 degrees celcius) n=24; 12 males, 12 females; age 22-45 Climate chamber

Evidence Table 10. Physical environment (continued)

Author Year	Outcomes	Results	Design Suitability/ Study Execution
Ainsworth 1993[221]	Performance: words typed, errors, ratio of errors per words typed	No significant differences for words typed, errors, and their ratio for the three colors.	Moderate FAIR
Stone 1993[222]	Performance: Managerial or computational task	Windows did not have an effect on performance.	Moderate FAIR
Buchanan 1991[223]	Dispensing errors were recorded by a pharmacist observer.	Error rates were significantly lower with the highest illumination level.	Moderate GOOD
Rosenberg 1989[224]	Performance in visual alignment task	Significant difference between window shapes (less error with square window). Significant difference between reticle-present/absent (less error with reticle present condition).	Moderate GOOD
Noweir 1984[225]	Accidents: Incidence; Frequency rate; Severity rate	No significant difference in incidence, frequency rates or severity rates.	Moderate FAIR
Kwallek 1988[226]	Number of typing errors	Subjects who were in blue room, and then switched to red room, made significantly more errors.	Least FAIR
Enander 1987[227]	Performance tests: color word vigilance, simple reaction time, key tapping. Dexterity tests: screw manual, thumb tapping	The cold environment did not affect the performance tests but impaired the dexterity tests.	Least FAIR

Evidence Table 11. Organizational factors

Study Year	Study Question(s)	Design/ Population/Setting	Consideration of Culture
Shortell 2000[265]	What is the impact of TQM and organizational culture on adverse outcomes among CABG patients?	Prospective cohort study of 16 randomly selected US hospitals w/CABG volume >200 procedures annually 3,045 CABG patients 864 administrators, nurses, and physicians	Supportive culture: provider perception of their involvement in decision-making and support to make necessary for improvement.
Aiken 1999[42]	Is Magnet hospital status associated with lower 30-day mortality among AIDS patients?	Cross-sectional study of 1,205 AIDS patients admitted to 40 units in 20 hospitals 820 nurses	Culture not considered explicitly Magnet status and nurse control of practice used.
Helmreich 1998[262]	What is the effect of national, professional, and organizational culture on errors and error management in aviation and operating rooms?	Descriptive: Cross-sectional with some longitudinal data Comparative: 15,000+ pilots from 22 airlines in 36 countries	Culture as attitudes and values; considers national, organizational, and professional cultures and notes importance of subcultures.
Aiken 1994[266]	Is Magnet hospital status associated with lower in-hospital mortality?	Cross-sectional study of 39 Magnet hospitals and 195 non-magnet US hospitals with more than 100 Medicare discharges	Culture not a specified variable. Magnet hospital status includes attributes associated with culture such as nurse autonomy, and collegial relationships.

*general findings noted but measures and results not reported
QI=quality improvement; MAE=medication administration errors; CQI=continuous quality improvement; CI=culture inventory
TQM=total quality management;CABG=coronary artery bypass graft; ADE=adverse drug event; RN=registered nurse;
AHA=American Hospital Association; AMA=American Medical Association

Evidence Table 11. Organizational factors (continued)

Study Year	Measures	Main Findings	Design Suitability/ Study Execution
Shortell 2000[265]	TQM-baseline used as part of stratification for sample selection TQM –Baldridge Scale Culture Inventory- 20 item Cost data Patient Outcome: 1) mortality 2) other adverse outcomes 3) functional health status (Rand SF36) 4) patient satisfaction	Little association between TQM/culture and quality/outcome variables.	Greatest GOOD
Aiken 1999[42]	Magnet status designation Clinical Environment Index (7 items) 30-day mortality rate	Magnet status, nurse control of practice and organization of care in dedicated AIDS unit associated with lower mortality and higher satisfaction.	Greatest FAIR
Helmreich 1998[262]	National culture: Hofstede tool and data	Strong professional cultures both impede and enhance safety.	Greatest FAIR
	Organizational and Professional Culture: Operating Team Resource Management Survey and Flight Management Attitudes Survey	Failures/errors occur at intersection of subcultures (e.g. surgeons and anesthesiologists).	
Aiken 1994[266]	Magnet hospital status designation ICD-9 casemix measure in-hospital mortality	Magnet hospitals have lower mortality rates than matched controls.	Greatest FAIR

*general findings noted but measures and results not reported
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Evidence Table 11. Organizational factors (continued)

Study Year	Study Question(s)	Design/ Population/Setting	Consideration of Culture
Kaminski 2001[278]	What are the relationships among organizational practices, injury rates, and productivity?	Cross-sectional 86 small manufacturing firms mostly located in Midwestern US	Teams
Maierhofer 2000[267]	Are manager and employee values related to compliance with wearing gloves among hairdressers?	Survey of 218 matched manager/employee pairs from 842 salons in an Australian state	Culture not considered explicitly. Values of preventive safety was independent variable.
Bond 1999[43]	What is the relationship of professional staffing levels and hospital occupancy and ownership with mortality rates?	Cross-sectional 3,763 general medical US hospitals	Occupancy Ownership Teaching affiliation
Schultz 1999[279]	What is the relationship of hospital characteristics and mortality due to AMI (acute myocardial infarction)?	Cross-sectional 373 purposively-sampled acute care hospitals in California	Profit status Total daily operating expenses Teaching status

*general findings noted but measures and results not reported
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Evidence Table 11. Organizational factors (continued)

Study Year	Measures	Main Findings	Design Suitability/ Study Execution
Kaminski 2001[278]	Lost-time injury rate: days away from work/100FTE Team: use or non use of teams Hours per week: average across employees	Inverse relationship between injury rates and hours worked. Positive relationship between injury rates and teams.	Moderate GOOD
Maierhofer 2000[267]	Scale developed for study - 7 point Likert type	Positive relationship between manager's and employee's prevention values, no relationship to safe behavior. Positive relationship between manager's and employee's time urgency and negative association with safe behavior.	Moderate GOOD
Bond 1999[43]	Medicare mortality rates from HCFA and AHA Hospital characteristics from AHA	Inverse association between ownership (Private, nonprofit and for-profit) and mortality rates. No association between teaching status and mortality rates. Inverse association between medical residency program size and mortality rates.	Moderate FAIR
Schultz 1999[279]	Profit status from AHA Total daily operating expenses from Statewide Office of Health Planning and Development database Teaching status from AMA	Relationship of teaching status to mortality rates was not signficant. Profit status and total daily operating expenses significantly and positively correlated with mortality.	Moderate FAIR

*general findings noted but measures and results not reported
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Evidence Table 11. Organizational factors (continued)

Study Year	Study Question(s)	Design/ Population/Setting	Consideration of Culture
Stetzer 1997[260]	Are employee perceptions of work climate related to workplace accidents?	Survey of 14,550 employees from 25 work divisions in large utility company	Climate and culture are similar. Shared cognitions of the work environment. Multiple different climates related to specific elements such as safety or absence.
Edmondson 1996[269]	How do group and organizational-level factors account for variance in drug error (ADE) rates across hospital units?	Cross-sectional study of 8 randomly-selected units in two urban hospitals	Not explicitly identified as variable, used 'social climate' and 'unit climate' (blame vs learning) to describe findings across several survey items and interviews.
Harter 2002[277]	What is the relationship between employee satisfaction-engagement at the business unit level and business outcomes, including accidents?	Meta Analysis 36 companies 7,939 business units 198,514 respondents 3 companies 121 business units had safety (accident) data	Employee satisfaction-engagement safety as outcome: lost workday/time incident or % of lost workdays.
Hechanova-Alampay 2001[270]	Does work team empowerment affect unsafe behaviors and accidents?	Survey of 531 employees of large chemical company in 24 workgroups across 3 US states	Culture not considered explicitly. Empowerment as independent variable.

*general findings noted but measures and results not reported
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TQM=total quality management;CABG=coronary artery bypass graft; ADE=adverse drug event; RN=registered nurse;
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Evidence Table 11. Organizational factors (continued)

Study Year	Measures	Main Findings	Design Suitability/ Study Execution
Stetzer 1997[260]	Employee ratings of workers' and supervisors' commitment to quality	Overall climate and subclimates of quality and cooperation associated with lower accident rates.	Moderate GOOD
Edmondson 1996[269]	ADE identified by daily chart review and informal unit visits; confidential reporting system Survey of unit social and organizational factors based upon measure used to study cockpit crews' performance Observation: semi-structured interviews of nursing and support	Quantitative: Higher error rates with better unit performance. Qualitative: Higher error rates with higher openness ranking with one exception.	Moderate GOOD
Harter 2002[277]	Gallup Workplace Audit (GWA)	Employee satisfaction-engagement correlated with all outcomes including the safety outcome, inversely.	Least GOOD
Hechanova-Alampay 2001[270]	Empowerment assessment: 21 item, 4 point Likert type scale completed by work team members trained in assessment Unsafe behavior: anonymous 18 item self-report survey	Empowerment was negatively correlated with unsafe behaviors and accidents.	Least FAIR

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Evidence Table 11. Organizational factors (continued)

Study Year	Study Question(s)	Design/ Population/Setting	Consideration of Culture
Wakefield 2001[271]	Are measures of nurses' perceptions of organizational culture and continuous quality improvement related to medication administration error reporting?	Survey of 297 nurses in 6 Midwest hospitals	Pattern of shared values, beliefs, and expectations.
Boreham 2000[268]	What are the sources of risk (avoidable increases in probability of adverse patient outcome)?	Case series of 25 critical incidents in two emergency departments in Britain over 30 months	Case series dependent.
Jones 2000[272]	What is impact of culture on work redesign initiatives?	Case series of 3 mid-sized community hospitals in West and Midwest Respondents not identified	Explicitly measured. Corporate culture as shared values and group behavior norms. Competing Values Framework: 4 cultural orientations: 1) Clan 2) Developmental 3) Market 4) Hierarchy

*general findings noted but measures and results not reported
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Evidence Table 11. Organizational factors (continued)

Study Year	Measures	Main Findings	Design Suitability/ Study Execution
Wakefield 2001[271]	Culture Inventory: 20 item QI Implementation Scale MAE Reporting Survey	Significant correlation of extent of CQI and culture at individual and unit level. Positive, non-significant correlation of CI, CQI, and reasons for not reporting error. Hierarchical and rational cultures negatively associated with estimated errors.	Least FAIR
Boreham 2000[268]	Critical Incidents Observations	Some latent conditions were organizational factors: power and status differential coupled with horizontal distribution of tasks resulted in breadkdowns in communication across organizational and professional boundaries.	Least GOOD
Jones 2000[272]	Culture Inventory Nurse satisfaction* Patient satisfaction*	Hospital w/balanced orientation most successful in implementing change & noted improvement in patient and nurse satisfaction scores. 2 other hospitals with increase in market and hierarchy had more difficulty and noted decrease in nurse satisfaction and latter also noted decrease in patient satisfaction.	Least POOR

*general findings noted but measures and results not reported
QI=quality improvement; MAE=medication administration errors; CQI=continuous quality improvement; CI=culture inventory TQM=total quality management;CABG=coronary artery bypass graft; ADE=adverse drug event; RN=registered nurse; AHA=American Hospital Association; AMA=American Medical Association

Evidence Table 11. Organizational factors (continued)

Study Year	Study Question(s)	Design/ Population/Setting	Consideration of Culture
Orbe 2000[273]	How do RNs communicate about and what factors govern reactions to organizational wrongdoing?	Case series of 202 critical incidents from 372 returned surveys sent to 1,900 randomly selected RNs in Midwest w/active licenses	Themes emerged from analysis related to culture: 1) workplace dynamics 2) professional ideals 3) consequences of reporting
Edkins 1997[276]	What are the human and organizational factors contributing to railway accidents?	Case series Retrospective analysis of 112 railway accidents and near accidents in Australia	Railway Problem Factors (RPF) managerial/organizational origins of accidents.
Shortell 1995[274]	Do organizational culture and quality improvement process affect estimated patient outcomes?	Cross-sectional study of 61 US hospitals primarily in the Midwest and West	Values, beliefs, and norms of an organization that shape its behavior.
Buller 1988[275]	What is the effect of team building and goal setting on task performance (productivity and quality)?	Time series 20 mine stopes (excavation areas) over 15 months	Teamwork and goal setting. Goal setting alone.

*general findings noted but measures and results not reported

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Evidence Table 11. Organizational factors (continued)

Study Year	Measures	Main Findings	Design Suitability/ Study Execution
Orbe 2000[273]	Self reports of incidents of wrongdoing	5 themes including: 1) workplace dynamics 2) tension between policy/reality w/workload 3) multiple informal ways of handling 4) not report if seen as minor 5) report if patient care or nursing standards compromised.	Least GOOD
Edkins 1997[276]	Railway Safety Checklist RPF identified through focus group of drivers and managers and refined to 13 by independent raters	15% of incidents attributable to organizational factors. 70% due to attentional factors.	Least POOR
Shortell 1995[274]	Culture Inventory–20 item QI Implementation–Baldridge Scale *Patient Impact Scale* – improved patient outcomes, reduced errors and inappropriate treatment, increased patient satisfaction, improved continuity of care *Financial Impact Scale* – reduced costs, increased profitability improved productivity/efficiency	Negative correlation between hospital bed size and culture (larger size associated with less group/developmental type culture). Significant association between group/developmental culture and QI implementation. Significant association between QI implementation and patient outcomes.	Least FAIR
Buller 1988[275]	Revenue/manshift Tons/manshift Grade of ore	Teamwork and goal setting had significant positive effect on quality. No effect of either treatment condition on production. Increase in revenue/manshift noted for both groups.	Least POOR

*general findings noted but measures and results not reported

QI=quality improvement; MAE=medication administration errors; CQI=continuous quality improvement; CI=culture inventory TQM=total quality management;CABG=coronary artery bypass graft; ADE=adverse drug event; RN=registered nurse; AHA=American Hospital Association; AMA=American Medical Association

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Appendix B: Search Strategies by Working Condition and for the Campbell Collaboration Database

Workforce Staffing

Database: MEDLINE

---

1 exp Medical Errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 workload/ or workload.mp. or overwork.mp.
13 exp professional competence/
14 work schedule tolerance/ or personnel turnover/ or teamwork.tw.
15 burnout, professional/
16 "Personnel Staffing and Scheduling"/ or personnel staffing.mp.
17 12 or 13 or 14 or 15 or 16
18 11 and 17
19 limit 18 to (human and english language)
20 limit 19 to yr=1980-2002

Database: CINAHL

---

1 Medication Errors/ or medication errors.mp.
2 Treatment Errors/ or medical errors.mp.
3 Diagnostic Errors/ or diagnostic errors.mp.
4 safety management.mp. or Safety/
5 Hospital Mortality/ or hospital mortality.mp.
6 iatrogenic disease/ or iatrogenic.mp.
7 Patient Safety/ or patient safety.mp.
8 *Treatment Outcomes/
9 Quality of Health Care/
10 patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 WORKLOAD/ or WORKLOAD MEASUREMENT/
13 Personnel Turnover/ or personnel turnover.mp.
14 TEAMWORK/ or teamwork.mp.
15 BURNOUT, PROFESSIONAL/
16 "Personnel Staffing and Scheduling"/ or personnel staffing.mp.
17 exp Professional Competence/og, pf, ev, st, td [Organizations, Psychosocial Factors, Evaluation, Standards, Trends]
18 12 or 13 or 14 or 15 or 16 or 17
19 11 and 18

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 error$.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Work Scheduling/ or exp Work Rest Cycles/ or exp Workday Shifts/ or work schedule.mp.
10 teamwork.mp.
11 exp *occupational stress/
12 exp work load/ or work load.tw.
13 exp Professional Competence/ or professional competence.mp.
14 9 or 10 or 11 or 12 or 13
15 8 and 14
16 limit 15 to human

Workflow Design

Database: MEDLINE

---

1 exp Medical Errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 Efficiency, Organizational/ or organizational efficiency.mp.
13 (workflow or work flow).tw.
14 exp "Task Performance and Analysis"/ or task performance.mp.
15 exp *Information Systems/og, sd, td, ma, ut
16 (equipment safety and patient$).mp.
17 *Equipment Design/ae, sn, td, mt
18 12 or 13 or 14 or 15 or 16 or 17
19 11 and 18
20 limit 19 to (human and english language)
21 limit 20 to yr=1980-2002

Database: CINAHL

---

1 Medication Errors/ or medication errors.mp.
2 Treatment Errors/ or medical errors.mp.
3 Diagnostic Errors/ or diagnostic errors.mp.
4 safety management.mp. or Safety/
5 Hospital Mortality/ or hospital mortality.mp.
6 iatrogenic disease/ or iatrogenic.mp.
7 Patient Safety/ or patient safety.mp.
8 *Treatment Outcomes/
9 Quality of Health Care/
10 patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 Organizational Efficiency/ or organizational efficiency.mp.
13 workflow.mp.
14 exp "Task Performance and Analysis"/ or task performance.mp.
15 exp *Information Systems/ma, og, st, td, ut [Manpower, Organizations, Standards, Trends, Utilization]
16 equipment safety/ and patient$.mp.
17 *Equipment Design/ae, st, ev, td [Adverse Effects, Standards, Evaluation, Trends]
18 12 or 13 or 14 or 15 or 16 or 17
19 11 and 18

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 error$.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Organizational Effectiveness/ or organizational efficiency.mp.
10 (workflow or work flow).mp.
11 equipment safety.mp.
12 (equipment design$ or design$ of equipment).mp.
13 (job performance or task performance).tw.
14 9 or 10 or 11 or 12 or 13
15 8 and 14
16 limit 15 to (human and english language)

Database: MEDLINE

---

1 exp Medical Errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 exp User-Computer Interface/
13 exp Expert Systems/ or expert systems.mp.
14 (diagnosis or screening or appendicitis or abdominal pain).mp.
15 13 and 14
16 (distraction$ or interruption$ or multi task$ or multitask$).mp.
17 closed loop control$.mp.
18 limit 17 to review articles
19 12 or 15 or 16 or 18
20 11 and 19
21 limit 20 to (human and english language)
22 from 21 keep 1-1048

Database: CINAHL

---

1 Medication Errors/ or medication errors.mp.
2 Treatment Errors/ or medical errors.mp.
3 Diagnostic Errors/ or diagnostic errors.mp.
4 safety management.mp. or Safety/
5 Hospital Mortality/ or hospital mortality.mp.
6 iatrogenic disease/ or iatrogenic.mp.
7 Patient Safety/ or patient safety.mp.
8 *Treatment Outcomes/
9 Quality of Health Care/
10 patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 exp Expert Systems/ or expert systems.mp.
13 (diagnosis or screening or appendicitis or abdominal pain).tw.
14 12 and 13
15 closed loop control$.mp.
16 exp User-Computer Interface/ or user computer interface.mp.
17 (interruption$ or distraction$ or paging or paged).tw.
18 14 or 15 or 16 or 17
19 11 and 18
20 from 19 keep 1-103

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 error$.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Expert Systems/ or expert systems.mp.
10 (diagnosis or screening or appendicitis or abdominal pain).mp.
11 9 and 10
12 closed loop control$.mp.
13 (distraction$ or interruption$ or paged or paging).tw.
14 exp Human Computer Interaction/
15 11 or 12 or 13 or 14
16 8 and 15
17 limit 16 to (human and english language)
18 from 17 keep 1-234

Personal/Social

Database: MEDLINE

---

1 exp medical errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 Job Satisfaction/ or job satisfaction.mp.
13 absenteeism/
14 Employee Grievances/ or employee grievance$.mp.
15 Burnout, Professional/ or professional burnout.mp.
16 professionalism.mp.
17 professional culture.mp.
18 MORALE/ or morale.mp.
19 Professional Autonomy/ or professional autonomy.mp.
20 professional power.mp.
21 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
22 11 and 21
23 limit 22 to human
24 limit 23 to english language
25 23 not 24
26 limit 25 to abstracts
27 24 or 26
28 limit 27 to yr=1980-2002

Database: CINAHL

---

1 (medical errors or medication errors or diagnostic errors).mp.
2 quality of health care/
3 *safety/ or safety/st or safety management.mp.
4 exp hospital mortality/
5 Iatrogenic Disease/ or iatrogenic disease.mp.
6 (patient safety or safety of patient$).mp.
7 *treatment outcome/
8 Patient$.ti.
9 Job Satisfaction/ or job satisfaction.mp.
10 ABSENTEEISM/ or absenteeism.mp.
11 Employee Grievances/ or employee grievance$.mp.
12 BURNOUT, PROFESSIONAL/ or burnout.mp. or Stress, Occupational/
13 PROFESSIONALISM/ or professionalism.mp.
14 professional culture.mp.
15 MORALE/ or morale.mp.
16 AUTONOMY/ or PROFESSIONAL AUTONOMY/ or autonomy.mp.
17 Power/ or professional power.mp.
18 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
19 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
20 18 and 19

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 error$.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Job Satisfaction/ or job satisfaction.mp.
10 exp EMPLOYEE ABSENTEEISM/ or absenteeism.mp.
11 employee grievance$.mp.
12 exp Occupational Stress/ or burnout.mp.
13 exp Professional Ethics/ or professionalism.mp.
14 exp Professional Identity/ or professional culture.mp.
15 exp MORALE/ or morale.mp.
16 autonomy.mp.
17 exp Power/ or professional power.mp.
18 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
19 8 and 18
20 limit 19 to human

Physical Environment

Database: MEDLINE

---

1 exp Medical Errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 exp "Facility Design and Construction"/ or facility design.mp.
13 exp Health Facility Environment/
14 (working environment$ or physical environment$).mp.
15 exp Air Pollution, Indoor/ or indoor pollution.mp.
16 indoor lighting.mp.
17 lighting/
18 acoustics.tw. or acoustics/
19 workplace.mp.
20 NOISE/
21 working conditions.mp.
22 exp "Interior Design and Furnishings"/ or interior design.mp.
23 HUMIDITY/ or humidity.mp.
24 indoor temperature$.mp.
25 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26 11 and 25
27 limit 26 to human
28 limit 27 to english language
29 27 not 28
30 limit 29 to abstracts
31 28 or 30
32 limit 31 to yr=1980-2002

Database: CINAHL

---

1 Medication Errors/ or medication errors.mp.
2 Treatment Errors/ or medical errors.mp.
3 Diagnostic Errors/ or diagnostic errors.mp.
4 safety management.mp. or Safety/
5 Hospital Mortality/ or hospital mortality.mp.
6 iatrogenic disease/ or iatrogenic.mp.
7 Patient Safety/ or patient safety.mp.
8 *Treatment Outcomes/
9 Quality of Health Care/
10 patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 exp "Facility Design and Construction"/ or facility design.mp.
13 exp Health Facility Environment/
14 Work Environment/ or working environment.mp.
15 physical environment.mp. or exp "Interior Design and Furnishings"/ or Noise/ or exp "Hospital Design and Construction"/
16 exp Air Pollution, Indoor/ or indoor air pollution.mp.
17 LIGHTING/
18 ACOUSTICS/ or acoustics.mp.
19 workplace.mp.
20 working conditions.mp.
21 HUMIDITY/ or humidity.mp.
22 *temperature/
23 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22
24 11 and 23

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 error$.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Human Factors Engineering/ or facility design.mp.
10 exp Facility Environment/ or facility environment.mp.
11 exp Working Conditions/ or working environment.mp.
12 indoor air pollution.mp.
13 exp Illumination/ or indoor light$.mp.
14 exp acoustics/
15 exp "noise levels (work areas)"/
16 exp Interior Design/ or interior design.mp.
17 exp Facility Environment/
18 exp Temperature Effects/
19 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
20 8 and 19
21 limit 20 to human

Organizational Culture

Database: MEDLINE

---

1 exp Medical Errors/
2 (medical errors or medication errors or diagnostic errors).mp.
3 quality of health care/
4 *safety/ or safety/st or safety management.mp.
5 exp hospital mortality/
6 Iatrogenic Disease/ or iatrogenic disease.mp.
7 quality assurance health care/
8 (patient safety or safety of patient$).mp.
9 *treatment outcome/
10 Patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 Organizational Culture/ or organizational culture.mp.
13 organizational climate.mp.
14 exp interprofessional relations/ and og.fs.
15 leadership/ and og.fs.
16 managerial style.mp.
17 management style.mp.
18 12 or 13 or 14 or 15 or 16 or 17
19 11 and 18
20 limit 19 to (human and english language and yr=1980-2002)

Database: CINAHL

---

1 Medication Errors/ or medication errors.mp.
2 Treatment Errors/ or medical errors.mp.
3 Diagnostic Errors/ or diagnostic errors.mp.
4 safety management.mp. or Safety/
5 Hospital Mortality/ or hospital mortality.mp.
6 iatrogenic disease/ or iatrogenic.mp.
7 Patient Safety/ or patient safety.mp.
8 *Treatment Outcomes/
9 Quality of Health Care/
10 patient$.ti.
11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12 exp Skill Mix/ or skill mix.mp.
13 exp Organizational Culture/ or organizational culture.mp.
14 organizational climate.mp.
15 *Interprofessional Relations/
16 Management Styles/ or management style.mp.
17 12 or 13 or 14 or 15 or 16
18 11 and 17

Database: PsycINFO

---

1 exp Job Performance/ or human performance.mp.
2 exp EMPLOYEE PRODUCTIVITY/ or exp Group Performance/
3 exp Person Environment Fit/ or person environment fit.mp.
4 (medical errors or medication errors or diagnostic errors).mp.
5 iatrogenic disease/ or iatrogenic.mp.
6 exp Hospitalized Patients/ or patient safety.mp.
7 1 or 2 or 3 or 4 or 5 or 6
8 exp Organizational Climate/ or organizational culture.mp.
9 organizational climate.mp.
10 exp Teams/ or interprofessional relatio ns.mp.
11 exp LEADERSHIP QUALITIES/ or exp LEADERSHIP STYLE/
12 exp Conflict Resolution/ or exp Leadership Style/
13 8 or 9 or 10 or 11 or 12
14 7 and 13
15 limit 14 to human

Campbell Collaboration Database
Social, Psychological, Educational, and Criminological Trials Register (C2-SPECTR)

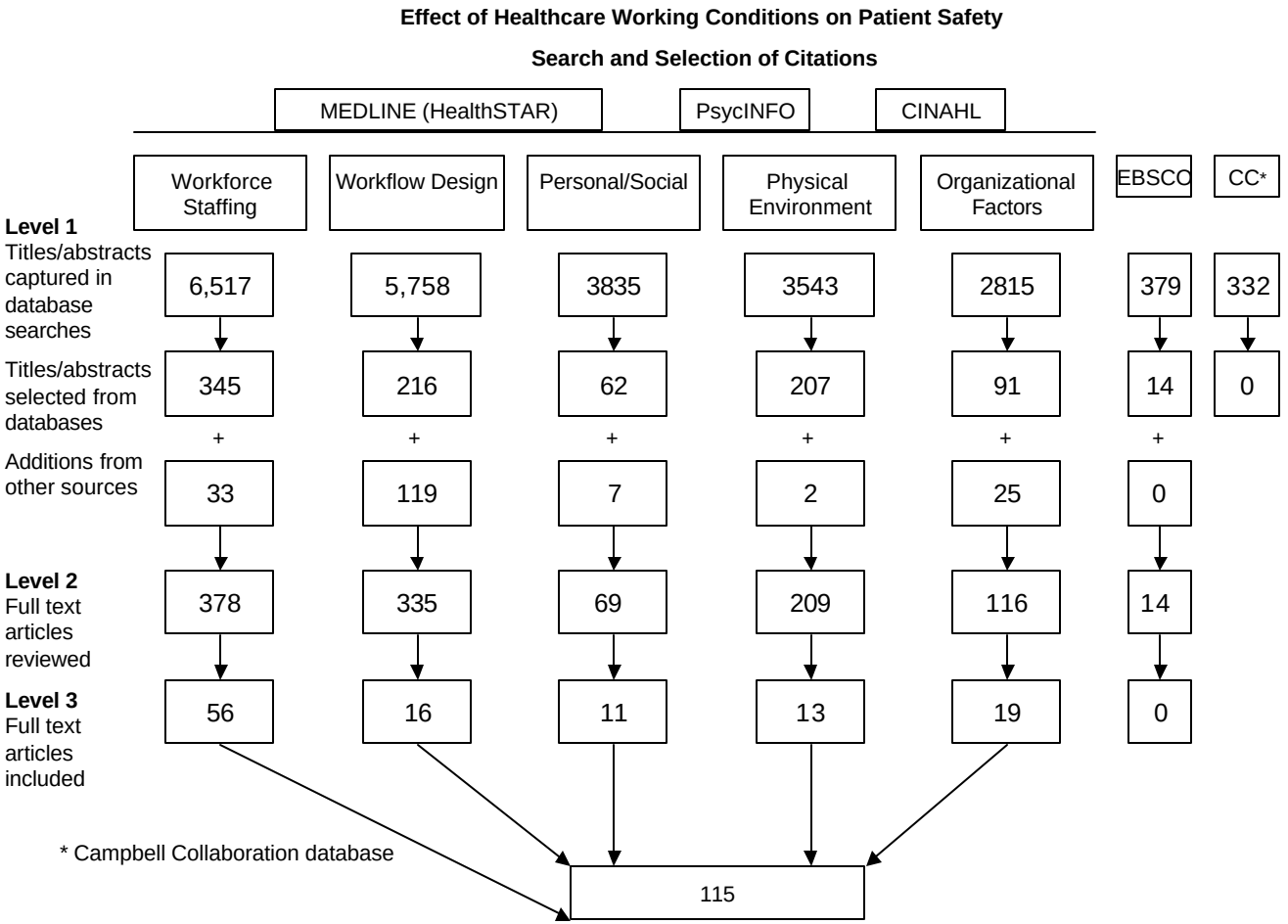
Database: Campbell Collaboration

---

1 patient and safety
2 safety
3 medical and error
4 error
5 error and safety
6 working and conditions
7 quality and health and care
8 medication and errors
9 diagnostic and errors
10 hospital and mortality
11 iatrogenic and disease
12 quality and assurance
13 treatment and outcome
14 job and performance
15 employee and productivity
16 person and environment and fit
17 human and performance
18 productivity

Note: We searched in the keywords and non-indexed fields.

Appendix C: Search Results



Appendix D: Data Abstraction Guidelines

Source

Author(s): _____

Editor(s): _____

Year: _____

Title: _____

Journal: _____

Volume (Issue) or Edition: _____

Publisher (Place): _____

Page(s): _____

Exclusion Code at the Paper Review Level (if applicable): _____

Study Design

Purpose of Study: _____

Industrial/Healthcare Setting: _____

Comparison Groups: _____

Working Conditions Measured: _____

Length of Followup: _____

Interventions: _____

Co-Interventions: _____

Blinding: _____

Sample/Population

Population: _____

Inclusion Criteria: _____

Sample Characteristics: _____

Groups/n: _____

Baseline Differences in Groups: _____

Non-respondents: _____

Exclusions: _____

Intervention

Description: _____

Procedure: _____

Duration of Intervention: _____

Measures/Analysis

Baseline Measures: _____

Outcome Measures: _____

Confounders: _____

Analysis Methods: _____

Outcome

Relationship of outcome to patient safety: _____

_____

Strength of association between working condition and outcome: _____

_____

Overall findings (Check one):

_____ Working condition affects patient safety.

_____ Working condition does not affect patient safety.

Comments: _____

_____

Quality

Study Design (Check as appropriate):

_____Randomized Controlled Trial
_____Cohort Study
_____Case Control Study
_____Cross-sectional Study
_____Case Series
_____Survey/Self-report
_____Pre-test/Post-test
_____Other

Comments: _____

_____

Internal Validity:

Comparability of Groups: _____
Differential Loss to Follow Up: _____
Measurement/Instrumentation Issues: _____
Maturation/Pre-testing Effects: _____
Clear Description of Interventions: _____
Other Issues: _____

External Validity (Check as appropriate):

_____Sensitized or Pre-tested Population
_____Specialized/Atypical Population
_____Selection Biases (non-random subject selection)
_____Reactive Effects of Experimental Settings
_____Multiple Interventions

Comments: _____

_____