Managing Fatigue in Operational Settings 2: An Integrated Approach

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The six domains that must be addressed in managing fatigue in operational settings are identified, and examples of how the aviation industry is dealing with the problems in each domain are given. Challenges facing healthcare providers in managing fatigue are also discussed.

Index Terms: *aviation, fatigue, healthcare professions, scheduling*

The personal countermeasures described in the previous article provided strategies for individuals to manage the fatigue-related challenges particular to their physiology and operational demands. However, sleep and circadian physiology are complex, and 24-hour operational requirements are varied. It is not possible, therefore, that a single approach or strategy will be successful in managing all fatigue factors engendered by 24-hour demands.

A comprehensive and integrated approach that addresses the many factors that affect fatigue in operational settings is critical. Six major domains should be addressed in an integrated program to manage fatigue in operational settings: (1) education and training, (2) hours of service, (3) scheduling practices, (4) countermeasures, (5) design and technology, and (6) research. In this article, we discuss factors that must be addressed in each of the domains and describe activities under way in the aviation industry in 1996 to manage fatigue in operational settings.

Education and Training

Development and implementation of education and training materials will establish the knowledge base for all other activities. The materials should provide information on the physiological mechanisms that underlie fatigue, address some of the misconceptions about fatigue, and make specific recommendations for countermeasures. Materials that are industry specific (presentations and written brochures, videos, classes, etc) should be developed.

Although a general knowledge base should be used, examples and strategies relevant to the particular setting are critical for utility and operator acceptance. The information should be distributed industrywide through various forums and formats. In addition to information transfer, the intent of this strategy is to foster behavioral change. The material should therefore be incorporated wherever appropriate and should be provided frequently. Follow-up support for implementation is critical. Issues ranging from quality control to use of the material can be improved through organized support for implementation. New countermeasures and research data are continually becoming available, and a mechanism for updates should be developed.

Example: An Education and Training Module

In 1994, scientists with the NASA Ames Research Center's Fatigue Countermeasures Program, in collaboration with the Federal Aviation Administration (FAA), developed an education and training module entitled Alertness Management in Flight Operations.[1] The module is a 1-hour live presentation that covers physiological mechanisms, misconceptions, and countermeasures. It is complemented by a NASA/FAA Technical Memorandum (TM) that includes the presentation slides and supporting text that elaborate on the information. The TM also includes appendixes with information on NASA studies, sleeping pills, and sleep disorders and a recommended reading list.

The module is distributed to the aviation industry through

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2-day workshops held at the NASA Ames Research Center. The workshops provide a train-the-trainer opportunity for transfer of background information and distribution of the module and other resources for use within the industry. As of December 1995, 15 workshops have been held for 300 participants representing 163 different organizations from 14 countries. A recent survey of participants indicated that 40 organizations currently have training programs in place and that these will reach about 65,000 flight crew members and others in the industry.

Another 12 organizations are developing programs that will reach about 12,000 additional persons. The workshop and materials are provided at no cost as a jointly sponsored NASA/FAA activity. Participants and sites of implementation have been extended to reflect all components of the aviation industry—commercial, military, corporate—and have been extended to medical, law enforcement, and other transportation personnel. The module is being revised for use in marine and trucking environments. The FAA has organized a working group to develop advisory material based on the NASA/FAA module, and this is to be distributed widely throughout the aviation industry.

Hours of Service

The number of hours that individuals work can be established by government regulation and company policies. This is especially true in areas in which the federal government is responsible for public safety. In some work environments, no policies or guidelines for work hours exist. Each operational setting should be encouraged to develop principles and guidelines for duty and rest scheduling that reflect the demands of that working environment. These principles and guidelines should incorporate and reflect the latest scientific research on fatigue.

It is critical that the specific guidelines include approaches that maintain operational flexibility and reflect the idiosyncratic demands of the industry. Representatives of the industry should be asked to contribute to developing the guidelines so that they reflect the diverse operational components of concerned industries. This issue can be most contentious because of its relation to economic considerations. Whenever possible, these discussions and guidelines should rely on scientific data balanced with the operational demands of the particular industry.

Examples: Developing New Regulations

The federal regulations governing the hours of service for airline flight crews' flight/duty/rest requirements were originally written in 1937 and were only minimally changed in 1985. These regulations have received attention because they were written before jet travel, do not reflect current aviation operations, and do not incorporate available scientific information on fatigue.

To address this issue, the FAA established an industry working group to examine the current flight/duty/rest regulations and to identify potential areas for change. This group met at various locations over an 18-month period from February 1993 to May 1994 and provided the FAA with three proposals to address the issues identified by the group. The FAA subsequently established a rule-making team that has drafted a new flight/duty/rest regulation that incorporates the working group's approaches and scientific information and attempts to reflect current operational practices in aviation. The proposed rule was published for comment December 14, 1995, with an extended 6-month comment period before further FAA action.

Corporate aviation operators, under the sponsorship of the Flight Safety Foundation, established a working group to develop principles and guidelines for duty–rest scheduling. The working group has drafted a document that is currently under review in the corporate aviation industry.[7]

Scheduling Practices

Beyond federal regulatory requirements and company policies, scheduling practices are another domain that can have a significant effect on fatigue. Whenever possible, scheduling approaches should attempt to incorporate scientific research on fatigue. Again, it is critical that operational flexibility be maintained to meet demands. It is possible to develop principles and guidelines specific to company operations. In many operational environments, the scheduling procedures incorporate a number of factors, including regulatory considerations, labor contracts, economics (from service requirements to moving equipment and personnel), changing markets, and seasonal demands. Other factors that could be incorporated are the sleep and circadian considerations described in detail in the preceding article. Each of these factors is weighted according to a company's priorities. At a minimum, the physiological considerations could be part of a company's scheduling algorithm. Future expert scheduling systems may incorporate these physiological considerations as a routine component of a company's practices.

Example: Flight Scheduling

Several major US air carriers have initiated activities to include the physiological findings on fatigue in developing schedules. One carrier established a working group to develop a flight schedule for a new destination that incorporated fatigue considerations. The working group developed some principles and guidelines, then created the specific flight schedule that addressed both the company needs (eg, passenger requirements, airplane capability) and fatigue considerations. The schedule was successfully implemented and continues to be flown as it was developed by the working group.

Another major US air carrier, after implementing the NASA/FAA education and training module, found that one category of questions regarding company scheduling practices was continually raised in the class. In response to these inquiries, management established an internal scheduling working group to develop principles and guidelines for their company and to identify specific flight schedules for application. This working group identified a particularly difficult flight pairing and suggested a specific alteration that better reflected the crew's physiological needs. The working group's recommendation are currently being implemented.

Example: Shift Work

Some European approaches involve rotating shift schedules over a matter of days (ie, fast rotation) compared with the usual US practice of rotating shift schedules over weeks (ie, slow rotation). The European approach is based on data suggesting that shift workers do not adjust to a rotated schedule and therefore should spend minimal time rotating their schedules.

Countermeasures

Fatigue countermeasures involve a range of strategies—personal, corporate, and regulatory. A first step is to provide (a) support for preventive and operational countermeasures, such as education and training, (b) sufficient resources, and (c) an appropriate environment for implementation.

Some approaches require company support. This could come in a variety of forms, from supplying trainers and providing class time to establishing rest areas and a corporate culture that supports discussing and addressing fatigue-related issues. More specific personal strategies are discussed in the preceding article. It is critical to emphasize that individuals have a personal responsibility to address these issues and incorporate strategies into their own lives. There are also regulatory approaches that extend beyond duty–rest issues, such as sanctioning empirically validated strategies and providing resources for information.

Examples: Rest Areas

All of the air carriers currently using the NASA/FAA education and training module are establishing a foundation for company support in addressing these issues. Providing the trainers, class time, and resources to implement the module is a concrete mechanism for managing fatigue.

Some overnight cargo companies have developed specific rest areas with lounges or bunks for flight crews waiting in the middle of the night for packages to be sorted. Many pilot organizations have established committees to address individual countermeasure strategies, educational information, scheduling practices, and company policies regarding fatigue.

A NASA/FAA study empirically demonstrated the effectiveness of a planned cockpit rest period in improving performance and alertness in long-haul flight operations.[2] Regulatory provisions that would sanction the appropriate use of planned cockpit rest are currently under review. Several non-US air carriers have already implemented the procedure.

Design and Technology

Although technology in our society continues to evolve with great speed, the human operators in the center of the advancing technology have not evolved at all in their need for sleep and circadian stability. Whenever possible, human-factor considerations, including issues related to fatigue, should be incorporated into the earliest stages of design before manufacturing begins or procedures are developed. Collaborations should be established with manufacturers to make design contributions on issues related to fatigue.

Another area that offers significant opportunities is the development and implementation of proven technological approaches. Potential technological areas include scheduling algorithms and alertness-monitoring/management systems. It will be important to address issues of reliability, validity, specificity, and sensitivity when offering empirical demonstrations of the effectiveness of technological approaches.

Examples: On-Board Crew Rest Facilities

Long-haul flight operations can involve extra flight crew to rotate through flight-deck positions when flying long hours. These aircraft are generally equipped with on-board rest facilities to allow flight crew to sleep while others are maintaining the flight. NASA/FAA research projects are examining these on-board crew rest facilities to determine the quantity and quality of sleep obtained and the factors that promote or reduce good sleep in the bunk. Their findings can provide data to manufacturers for building current aircraft and developing future designs.

The flight deck computer systems that support operations are another design issue. As aviation operations become more automated, the human operator becomes a passive or at least less active monitor of these systems. One example of using the technology to address fatigue issues is an alertness warning system that Boeing has included as an option on its 747–400 and 767 aircraft. This system alerts the flight crew when no interaction with the flight deck computers has occurred during a certain time period. If no response is after a predetermined interval, the signal's intensity is increased to initiate a response. This system is in operation on several long-haul aircraft, and flight crews have reported success in using it.

Research

Although a tremendous amount of scientific information is now available on fatigue, sleep, and circadian physiology, much is still unknown. This is especially true in the application of this scientific knowledge to operational issues. More research will be required to identify and generate data that address specific operational issues. For example, specific research should be conducted to address regulatory, scheduling, and countermeasure questions.

Although personal experience and anecdotal reports have a role in guiding certain research questions, empirical data are critical for decision making in highly visible and safety-related areas. The data should also guide discussions of the cost–benefit considerations of implementing countermeasures or scheduling practices. This research should combine appropriate methods (eg, field, simulator, laboratory) and make use of a range of measures (eg, performance, physiology, behavior) to address these issues. The data should help to quantify benefits and identify potential economic effects. Some research questions can address industrywide issues, and other activities may involve company-specific research. New results from continuing research activities should be returned to each of the five domains previously identified.

Examples: NASA Ames Program

Since 1980, the NASA Ames Fatigue Countermeasures Program has actively examined fatigue-related issues and the development and evaluation of countermeasures. Research approaches and measures have evolved to reflect the operational issues of the current aviation environment. Fatigue in commuter and regional airline operations, corporate aviation, and flight operations in two-person long-haul automated ("glass") cockpit aircraft is currently being studied by NASA Ames research scientists.

Healthcare Challenges

The issues raised throughout these articles pose challenges to the 24-hour requirements of healthcare personnel. Although we have offered specific examples from aviation, parallel activities are needed in healthcare environments.

Findings from a recent survey of US medical schools and training programs revealed that formal instruction about sleep, sleep disorders, and sleeping medications is minimal.[3] Clearly, healthcare workers provide a critical opportunity for the identification, treatment, and referral of sleep complaints and disorders. An obvious starting point is the development and distribution of educational materials that will create a much-needed knowledge base for healthcare providers.

The need for institutionalized educational efforts for healthcare has been identified by the National Commission on Sleep Disorders Research.[4] Successful efforts in this area are under way. The American Sleep Disorders Association and the National Sleep Foundation have created model educational programs that target specific specialties and sleep disorders. The National Commission also addresses the issue of costs to individuals and society associated with undiagnosed sleep disorders.

In the discussion of personal strategies for fatigue countermeasures, a range of interventions relevant to diverse sleep complaints are provided. A large body of scientific literature dealing with the diagnosis and treatment of sleep disorders is also available for healthcare workers, including textbooks[5] that describe the full range of sleep disorders, diagnostic methods, and treatment approaches.

In addition to the nonpharmacologic approaches described in the previous article, sedative or hypnotic medications can provide a safe, short-term intervention for the treatment of some sleep complaints. Sleeping pills are widely used and deserve some attention to help us clarify their appropriate application, their positive effects, and potential adverse effects.

Many sleep complaints are managed well in a primary-care setting with a knowledge base of diagnostic considerations and treatment alternatives. The American Sleep Disorders Association accredits sleep disorder clinics; individual sleep disorders specialists can be certified by a Board of Sleep Medicine. These clinics and individuals provide specialized knowledge, experience, and facilities for the diagnosis and treatment of sleep disorders.

Medical internship and residency are often cited as examples of the 24-hour challenges faced by healthcare personnel in which fatigue can play a role in quality care. No magic number dictates work hours or perfect scheduling practices. Some industries, such as transportation, involve federal regulatory agencies that set requirements for hours of service. These regulations are often complex and contentious. Industries have also developed principles and guidelines to provide some assistance to operators attempting to address these difficult issues.[6,7]

Conclusion

Clearly, no single cure or magic bullet can eliminate fatigue from 24-hour operational settings. Operational demands, human physiology, and individual differences are too complex for a simple mechanistic approach. By examining each component of the system, however, one can identify areas in which to incorporate current scientific knowledge regarding fatigue. The largest effect will be obtained by managing each component and attempting to maximize results in each domain. It will be critical for approaches to maintain operational flexibility to meet 24-hour global requirements. The challenge is to incorporate fatigue-related knowledge while balancing the need to meet operational demands.

As operational, global, and technological demands evolve, it will be important to identify and respond to emerging issues. The task of managing fatigue in operational settings is a shared responsibility among individuals, companies, federal agencies, scientists, industry organizations, and the public. The ultimate goal remains to maintain and, whenever possible, enhance safety, performance, and productivity in 24-hour operational settings.

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