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Model of safety inspection

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ABSTRACT

Safety inspection is a common element of safety management systems but has been subject to little scholarly research. A naturalistic study conducted in the amusement ride inspection domain identified key features of the task and derived a model fitting the inspection process independent of experience. A survey extended to two additional safety inspection domains supported the central features of the task description including generalist assignment of safety inspectors, high complexity, consecutive use of checklists, risk-informed decision making, and lack of performance feedback. Inspectors adapted to differences in knowledge and familiarity by using strategies to resolve uncertainty, including search for permissive sources and distributed cognition. The model provides a framework for development of strategies to support inspectors and to aid novice knowledge acquisition.

1. Introduction

Inspection is a common element of safety management systems, controlling hazards by early detection and correction. Inspection is a part of internal safety management systems as well as external or enforcement systems. This paper focuses on safety inspection as performed in many settings including occupational health and safety, public health, and technical standards inspection, using specific examples from amusement ride inspection. This paper focuses on *inspection* of conditions and operation, in periodic or occasional inspections. The scope of the study excludes adjacent practices such as what is often referred to as *auditing* of administrative program elements such as training attendance, availability of documentation, and statements of policy, although this may also be performed by the same inspectors on the same occasion. It also excludes hazard analysis and control, which are steps that may be performed to determine specific modification requirements once hazards have been identified.

Although seemingly a ubiquitous practice, the literature does not discuss safety inspection performance in relation to determinants of performance or objective validation of performance (i.e., within the "inclusion" box in Fig. 1). A literature search for "safety + inspection" in full text content within peer-reviewed literature in a general electronic database with a scope including and extending beyond human factors, ergonomics, psychology, and safety science literature 2000–2011 found no quantitative or qualitative studies within the scope of inclusion. Rather, the papers related to safety inspection addressed other relationships illustrated in Fig. 1, outside the scope of this paper.

Occupational safety textbooks describe safety inspection as though the actual search and assessment of defects is self-evident. The emphasis is on the need to plan the inspection, incorporating information about prior accidents, a review of operations and potential accidents, the hazard-identification input of workers, and applicable standards (Reich, 1986; Mansdorf, 1993). Texts commonly describe principles and standards related to a variety of hazard types, but the implication is that the inspector will intuitively know how to locate, identify, and correctly assess those hazards when they exist. While it may seem naïve to think of inspection decisions as unambiguous pass-fail choices, this is generally how they are described.

The contribution of human factors to inspection performance has been reviewed (Drury, 2001). Much of the literature has focused on quality inspection. However, Drury and Prabhu (1996) studied aircraft inspection, describing it as having predetermined defect types and criteria by which inspectors could receive performance feedback. Their paper described a somewhat individualized approach that incorporated individual inspectors' experience, training, distributed knowledge, and mental models in shaping the search for defects. Wilson et al. (2009) mentioned well-known human factors as pertinent to performance of grain inspectors in Australia, and noted the need for a wide range of skills and knowledge, mental preparation, and challenges with differences in scale and the sheer variety of inspected premises. A variety of task, inspector, device, environment and organizational challenges were identified in amusement ride safety inspection in a preliminary report from this research program (Woodcock, 2003). Despite these

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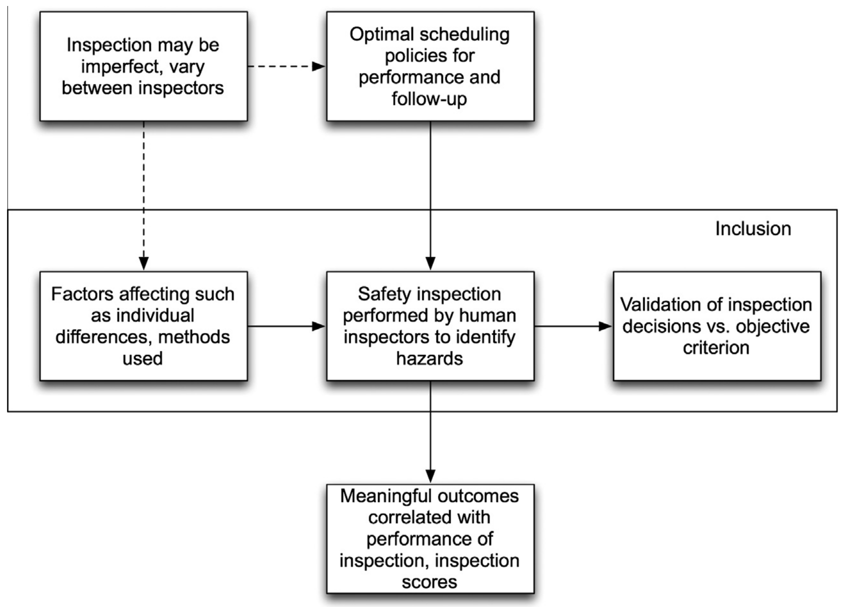

Fig. 1. Model of safety inspection literature inclusion criteria.

studies, there remains little literature that breaks down the safety inspection task and identifies how its decisions are made.

Research examining safety management systems treat inspection implicitly. Inspection is sometimes described by the process (analyze crash data, make a site visit) providing only broad outcome goals: ensure [road] safety impacts [of road projects] are in the acceptable range (Li, 2010). Sometimes the description of inspection clarifies the outcomes to be prevented (risks of slipping, falling objects, and drowning) and some sources of hazard (lighting, vibration, noise, and weather) but also includes vague expectations such as to ensure that risks of the work environment have been "considered" (Lind et al., 2008). A list of inspection items (food obtained from approved source, at proper temperature, and handled with minimum contact) refers to over 70 items in total, and seems to be thorough, except on examination it is clear that the inspector must determine what is "proper" based on objective knowledge, make qualitative decisions (whether contact is "minimum") and identify threats to broad requirements such as food protection (Murphy et al., 2011). In these examples, many checkpoints are vulnerable to individual differences in perception, knowledge, and judgement as they specify neither the means to evaluate nor criteria for determining adequacy of the item. Inspectors in focus groups themselves noted variation in the application of regulations, as "a lot of different interpretations of those grey areas" (Pham et al., 2010).

Grey areas are inherent to the present policy environment in many domains that favors risk-informed decision-making (Beardsley, 2008; Etherton, 2007; Mangalam and Feo, 2006). In this practice, safety inspectors may give owners time to correct a nominal defect with minimal safety implications, while more serious defects would be addressed more strictly, perhaps even with an immediate shutdown. The requisite discretion imposes further complexity, particularly for novices. The inspector must not only recognize indicators of defects but often must also be able to legitimize a decision based on risk. Immediate shutdowns may be challenged by operators, while time to comply may ultimately be questioned in the media if the operation experiences a catastrophic failure pending compliance. Inspectors play a role in the safety management system, known to be subject to social and political forces (Reason, 1997).

1.1. The task of safety inspection

Regulatory safety inspectors may visit multiple different and often unfamiliar premises each day, and are responsible to find any possible sources of hazard in a device, place, or process embedded in its natural environment. Inspected systems—e.g., devices, places, and the activities of people—are diverse and even one-of-a-kind. Rather than defining a defect prior to inspection and then tasking an inspector to search for it, and even specifying where it will be located if it exists, the safety inspector is tasked to identify potential instances of hazards that are often not fully defined. In some cases, the hazards are not defined at all, but rather implicit in the broad responsibility to prevent adverse outcomes. In some cases, even the types of adverse outcomes themselves are not fully specified.

Generally, all defects must be found so that they may be corrected to restore the safety of the operation. Potential defects are described only in general terms. For instance, "cracks" or "defective welds" can be defined as types of defect, but may occur in different places on different devices, and may be critical on some and cosmetic on others. Inspectors are also looking for potential mechanisms whereby certain broadly defined outcomes can occur, for instance falls, lacerations, or device collapse.

This variability requires what Rasmussen (1986) described as a topographic diagnostic search in which the operator compares the whole of what is currently being observed to a recollection or impression of a normal version. However due to the variety and novelty on a daily basis, safety inspectors may have no recollection of a normal version. Inspectors must construct a "normal" from abstract knowledge, subjectively similar devices perceived to be valid comparators, and other sources. The safety inspector must physically reposition himself to collect the necessary observations, requiring him to figure out where to go as well as how to make the observations.

In task performance such as firefighting (Klein et al., 1986) or troubleshooting (Schaafstal et al., 2000; Harris, 2008), professionals make decisions, act on the decisions, and find out the results of the action, and can then make the next decision. In addition, these professionals know there is at least one fault and need to identify and resolve the fault. In contrast, with safety inspection,