Hospital alarms blend together, fail to alert caregivers of emergencies

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The failure of hospital caregivers to respond to medical alerts is often attributed to "alarm fatigue"—the idea that nurses or doctors can become desensitized to the nonstop cacophony of beeps that patient-monitoring devices make.

A growing field of research suggests another possible explanation: alarms sounding simultaneously can blend together, making one or more of them inaudible. The phenomenon, known as masking, can make it difficult for caregivers to differentiate alarms, including those that signal life-threatening emergencies.

Now, a University at Buffalo-led research team is developing a computer-based tool—using the same principles as MP3 audio files—to identify these auditory blind spots. The effort, which is funded by a $750,000 U.S. Department of Health and Human Services grant, may help reduce preventable deaths associated with alarm system failures.

"It's an important but understudied problem. When you have a hodgepodge of different machines from different vendors, everything is sort of thrown together without much thought given to the coordination of them," says Matthew Bolton, PhD, assistant professor of industrial and systems engineering at UB, and the study's lead author.

A growing problem

Patient-monitoring alarms help caregivers perform their jobs. However, too many alarms can be problematic. According to the Joint Commission, a nonprofit that accredits hospitals, one patient can trigger hundreds of alarms each day. This corresponds to thousands of alarms daily from a single unit, and tens of thousands hospital-wide each day.

All the alerts can lead to alarm fatigue, which along with other alarm system failures were linked to 138 reported deaths between 2010 and June 2015, according to the Joint Commission.

Because "alarm masking is an extremely challenging problem to identify," Bolton says, it is unclear how many of those alarms went unanswered because the sound from another alarm rendered it inaudible. But the Joint Commission has acknowledged that individual alarm signals can be difficult to detect, and that this phenomenon is at least partially responsible for the patient safety problems associated with medical alarms.

The problem of alarm masking is exacerbated by the excessive number of alarms, and because alarms are often melodies of tonal sounds, which easily mask each other, Bolton says.

Tapping into MP3 code

To address the problem, Bolton researched the science behind audio file formats. Among those he examined was MP3, the popular audio coding format launched in the 1990s, which uses sophisticated models of human hearing to compress audio data by removing sounds that are masked.

Bolton combined these human hearing models with model checking (an automated, computational approach for finding problems in complex systems) to assess masking in a common patient-monitoring device with six different alarms.

He found that each alarm could be at least partially masked when other alarms went off simultaneously, and that one high-priority alarm could be completely masked.

"It's distressing because this is only one machine," Bolton says.

Future plans

Analyzing an alarm system, such as the one described above, can take days. However, Bolton is refining the method to shorten that time period; it now takes roughly 20 minutes to run a typical alarm system masking audit, he said.

The effort is supported by Health and Human Services, which awarded the three-year, $750,000 grant through the Agency for Healthcare Research and Quality. Bolton will use the tool to analyze and make recommendations for improving the international medical alarm standard (IEC 60601-1-8).

He is working with the Association for the Advancement of Medical Instrumentation (AAMI) Foundation, which is responsible for revising the standards for alarm sounds to reduce masking.

The research is described in greater detail in the journal *Applied Ergonomics* under the study "A formal approach to discovering simultaneous additive masking between auditory medical alarms."

More information: Bassam Hasanain et al. A formal approach to discovering simultaneous additive masking between auditory medical alarms, *Applied Ergonomics* (2017). DOI: 10.1016/j.apergo.2016.07.008

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