Improve safety by looking for "wheel nut indicators"

Harold Thimbleby

We all make errors from time to time, but when they happen in a hospital it is a short step to newspaper headlines about them. The media like the "human story" and the obvious human story is a nurse made a mistake and in an instant turned from being an angel of life to a bringer of death. The witch-hunt typically drives the storyline. Yet closer analysis shows the error is only an incidental part of the story, but the rest of the story is more complex and harder to grasp. In what is called the "bad apple" approach, by focusing on the individual human who is to blame, the larger system issues need not be addressed. If the nurse is a witch and leaves the job, then the problem is solved, like removing a bad apple from a barrel. Yet the system that allowed the error need not change, except perhaps to agree to providing a bit more training. Even agreeing to "human factors" training still effectively blames the hands-on practitioners rather than the systems.

Even the international standards (e.g., ISO 62366, "Medical devices — Application of usability engineering to medical devices") on medical device design spend time discussing human error, and taxonomising it into its various categories, such as mistakes, slips and abnormal behavior. Even in device design, then, human error is portrayed as an individual user problem. Ironically, while the standard tells us the difference between a user slip and a mistake, it provides no suggestions about how the system the nurse might be using could respond to them differently. In fact, I'd argue, it is not a device design standard as such, but a way for manufacturers to control their liabilities. Many approved devices break well-known usability and safety guidelines; in our current culture, the aim is not so much to make safe medical equipment, but to follow processes to show that products reach minimal standards. Hospital procurement has an impossible task selecting safer products, and is generally led by cost.

All medical devices are different, which causes problems in its own right. A hospital with several types of infusion pump will cause errors: a nurse practiced in using infusion pump A may make a mistake on infusion pump B because they are using it in the right way — for pump A. It is a bit like if cars had accelerator and brake pedals in arbitrary positions, you would not be surprised if drivers occasionally got them confused. You would not blame the drivers, but the manufacturers for not agreeing a standard for sorting out safety critical parts of the design. If a hospital fills up with a single manufacturer's devices to avoid this problem, that then raises a different problem: if there is a recall or other common mode problem with the devices, all of them go out of action.

If there is a mix of devices, you guarantee — *induce* is the technical term — user errors; if there is only one device you risk all of them failing at once. Hospital procurement has no way to make the tradeoff, other than to notice they'd be blamed if all of the hospital's equipment failed on the same day. Thus the system conspires, not deliberately, to put the onus of error management on the clinicians at the bedside. After all they are cheaper to replace than refitting the entire hospital.

How bad is it really?

Because of standards, we expect the brake and accelerator pedals to be in the same order, even for European, British and US cars. Yet the BodyGuard 545, an infusion pump, has up/down arrow keys overloaded either on the digit keys 2 and 0, or on 5 and 0, and the decimal point either to the left of 0 or to the right of 0; the details just depending on the particular model version. One hopes no hospital has both versions.

Patient care often involves drug dose calculations. Take any handheld calculator and make a keying error, such as pressing the decimal point twice in a row. A calculation involving 25..3 obviously has a keying error, and the final answer you get will be unreliable. I know of no calculator that detects this keying error. Many calculators provide a DELETE key to correct errors; if you can find one, try keying 25.. DELETE 3 and on most you will get 2.3 as the final number. Here, the error correction itself induces errors, when it was supposed to be there to reduce errors! This is a simple example that can be explained briefly; almost all medical devices have similar problems (Thimbleby, 2013). Although software errors are behind almost a quarter of all device recalls, these sorts of design problems are not noticed by manufacturers and do not lead to recalls — they remain the users' problems.

It is important to distinguish between errors, which do not matter, and patient harm which does. If you can make an error (like keying too many decimal points) this does not matter if it can be corrected (by pressing DELETE in this case). However, to correct an error assumes you can become aware of it. In our experiments, we have found people miss about 4% of their keying errors (Oladimeji *et al*, 2011). Some of these errors may not be major problems even if they remain undetected and uncorrected, but some are. It is then interesting

to know why we miss so many errors. Oladimeji used eye tracking systems to see where people were looking; often they look at the buttons to press, and don't look often enough at the displays to see if errors occur. We have found that redesigning the user interface can halve the number of errors, simply by helping users become more aware of them. This is exciting, and suggests useful ways of reducing errors in hospitals. Interestingly, if we could get manufacturers to adopt these ideas we would reduce errors and patient harm without needing any new user training. Everybody benefits from improvements to the systems. It is a bit like saying when you have a car accident, we could retrain you to be a safer driver — or we could put new tyres on your car to halve you stopping distance so you don't hit things in the first place.

My favourite example are "wheel nut indicators" — little yellow pointers you see on lorry wheels. A loose wheel nut is an error, that if uncorrected can lead to accidents, like a wheel falling off and the lorry losing control. Yet drivers cannot notice loose wheel nuts, so you could imagine we ought to train drivers to check nuts frequently, and even with training it turns out to be hard, because of the pressures and pacing of doing a hard job. Who is going to get out a wheel brace and check 50 nuts one by one before every journey? Instead, you put wheel nut indicators on the nuts and immediately any loose nuts are obvious, even to a driver in a hurry. So a cheap bit of plastic turns a complex safety, training and performance problem into almost automatic behavior. Unfortunately when we look at medical systems, and complex ones in particular, like infusion pumps and linear accelerators, "wheel nut indicators" are almost completely absent.

When an adverse incident occurs, it is inevitable that human error will be identified as a root cause. Somebody did or didn't do something, and in hindsight if things had gone differently, then the harm would not have occurred. This is called hindsight bias; it is quite likely that the correct course of action was not known or even knowable to anybody at the time. But there are two useful rules of thumb: if anybody else could have made the same mistake leading to the same consequences, the outcome was not caused by that specific person but by the system as a whole; secondly, if we could have modified the system to make the error more obvious at the time, so it could have been better managed — if there had been a missing wheel nut indicator, as it were — then the outcome was caused by a *latent* error, and the obvious active error that makes the newspaper headlines was in fact itself caused by the latent error.

Certainly, fixing the system is harder than blaming individuals one at a time, but the long term benefits are unlimited. If you are a manufacturer, fixing a device (or IT system) will benefit everybody who uses it, so although fixing the system seems hard, if we can persuade manufacturers to improve, the benefits will be as large as their markets. Closer to home, if you are in hospital or trust procurement, selecting safer systems will improve everybody's life, probably without them even noticing!

Prof Harold Thimbleby is a computer scientist and honorary fellow of the Royal College of Physicians. He became aware of problems in healthcare computing when one of his students was run over and had a time in intensive care twelve years ago. He is part of the CHI-MED project, www.chi-med.ac.uk, and his own web site www.harold.thimbleby.net has many relevant resources and movies that will be of interest. Useful resources are also available from www.chfg.org, the web site of the Clinical Human Factors Group.

References

Patrick Oladimeji, Anna Cox, Harold Thimbleby, "Number Entry Interfaces and their Effects on Errors and Number Perception," *Proceedings IFIP Conference on Human-Computer Interaction*, **IV**:pp178–185, Springer-Verlag, 2011.

Harold Thimbleby, "Improving Safety in Medical Devices and Systems," *Proceedings of the IEEE International Conference on Healthcare Informatics 2013* (ICHI 2013), in press, 2013.