
MAKE IT BETTER
DESIGNING OUT MEDICAL ERROR

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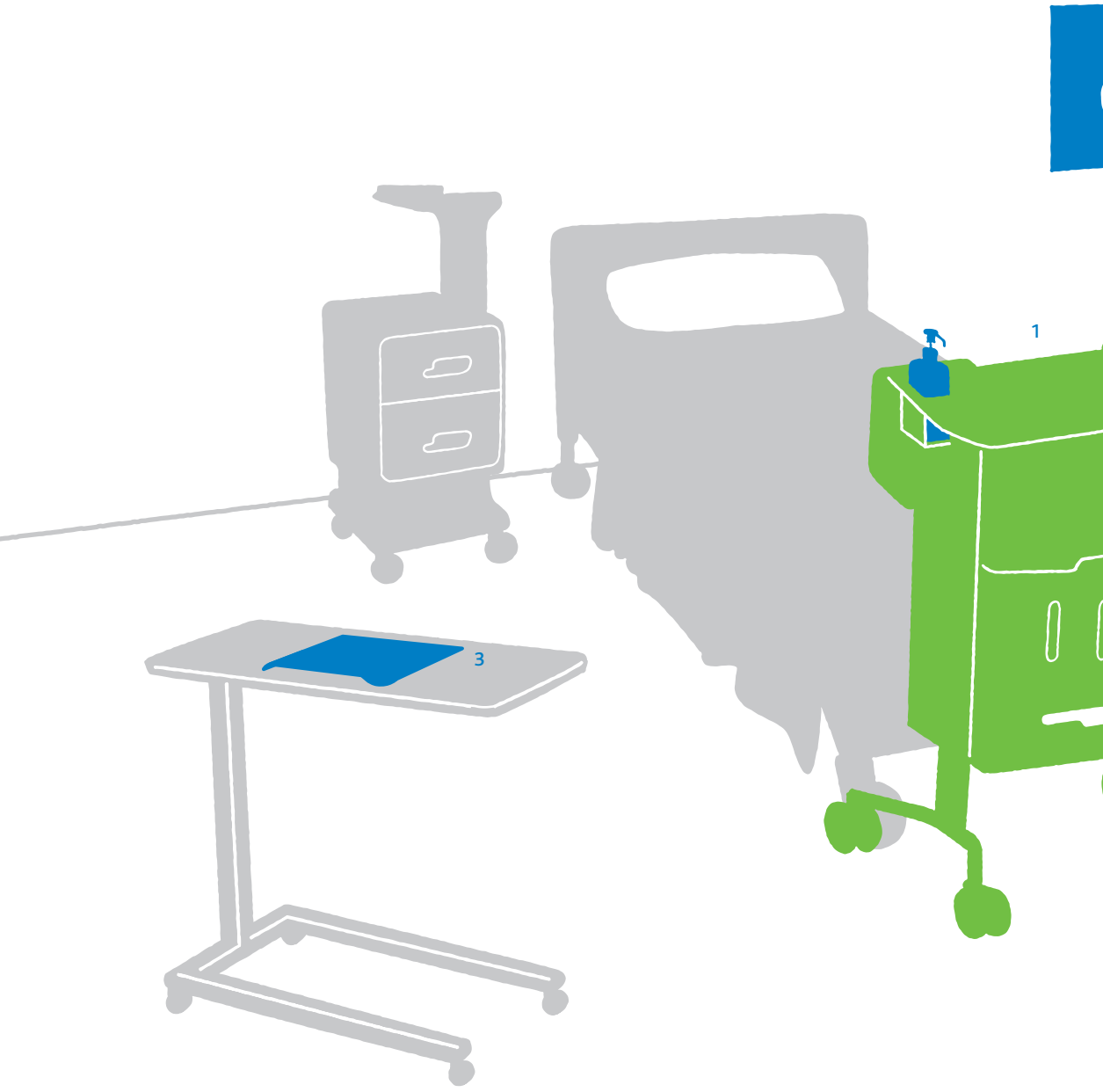

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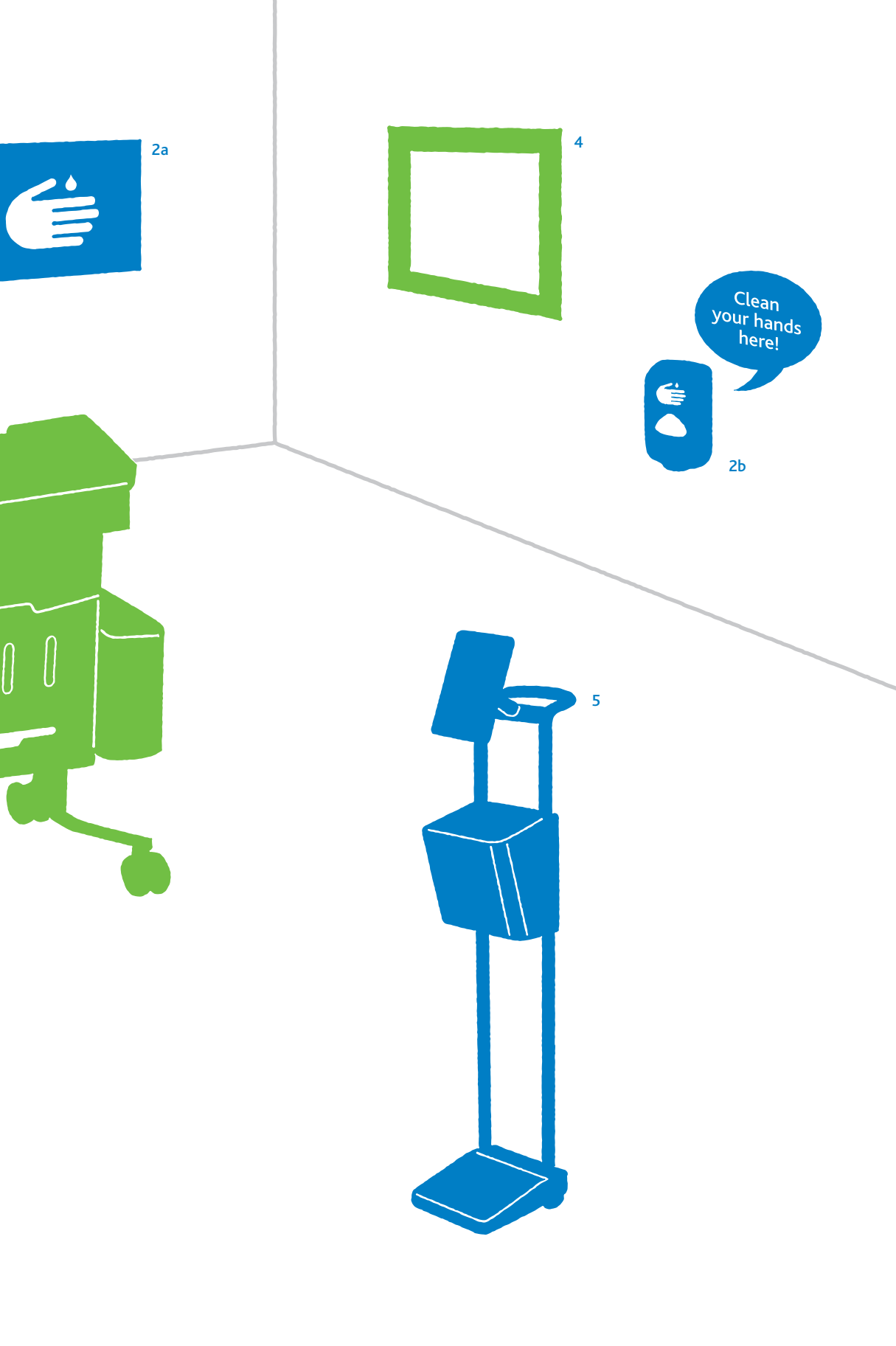
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Foreword

Roger Coleman
Chair of DOME Advisory Board
Professor Emeritus
Royal College of Art

Evidence suggests that something goes wrong in one out of every ten hospital admissions.

The causes of medical error are many, but rather than point the finger of blame we need to understand why they happen, identify those that can be avoided and develop ways to design them out of the system. This is easier said than done, as the causes are complex and the variables many.

Three crucial and interlocking elements lie at the heart of modern healthcare – team, process and equipment. Change one element and we change the others. That means design interventions must change behaviour and be welcomed by hard-pressed hospital staff as a way of delivering better, safer care to their patients.

That was the challenge we took on in planning the DOME (Designing Out Medical Error) project. To meet that challenge we brought together a team of hospital staff, safety experts and process analysts from Imperial College London and St Mary's Hospital with our own designer-researchers from the Royal College of Art. Our hypothesis was that to enable better, safer care for patients we must tackle all three elements together in a way that empowers our clinical partners.

The exemplar designs that you see in this publication are the proof of that hypothesis, but the real outcome of DOME is more than a set of design concepts – it is the validation of a collaborative research and design process that really can deliver better, safer healthcare. We believe the process is robust and repeatable. Trials on the ward will tell us if we are right or wrong.

Introduction

This publication, Make It Better, presents the design outputs from the DOME (Designing Out Medical Error) project, a three-year study funded by the EPSRC (Engineering and Physical Sciences Research Council).

The DOME project was set up with the aim to better understand and map healthcare processes on surgical wards – and establish an evidence base to design equipment and products that better supports these processes and therefore reduce instances of medical error.

A single multidisciplinary team was assembled from among research staff at the Helen Hamlyn Centre for Design at the Royal College of Art, Imperial College London and St Mary's Hospital, Paddington – bringing together designers, engineers, clinicians, ergonomists, psychologists and business academics in the fields of design, patient safety and management.

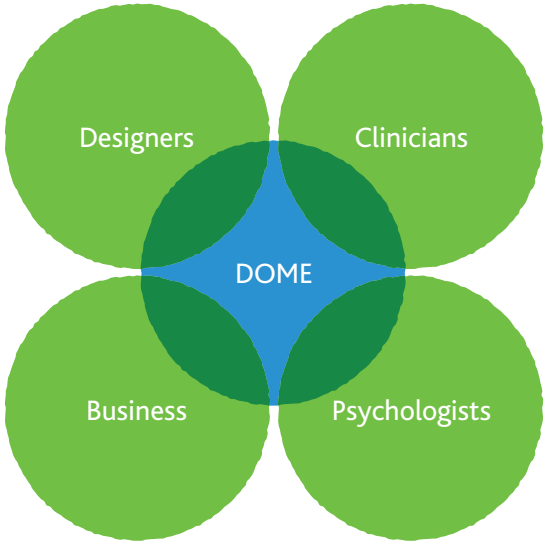
Problem Definition

A fundamental part of the Hippocratic Oath is *Primum non nocere*: 'above all, do no harm'. Though modern medicine is ever advancing, no individual, system or environment is perfect, and mistakes are made.

This issue of medical error in hospitals is high on the political agenda and is rarely out of the news. Human errors and systemic failures lead to preventable harm and unnecessary suffering for patients. In the UK, research suggests that as many as one in ten patients in hospital may suffer the effects of error in care, resulting in costs of £2 billion annually. It is estimated that over half of these cases may have been avoidable.

Healthcare processes continue to evolve whereas the design of much ward-based equipment remains largely unchanged. Daily patient care involves a complicated interaction of many tasks and processes, supported by products that co-exist within the patient's bed space. However, products are often designed with little thought for safe integration and context of use.

Design skills are often engaged late in the stage of development of hospital equipment, and as a consequence the designs can show little regard for the systems in which they work. In short, current treatments are not effectively supported by available equipment.



A multidisciplinary approach

The DOME study took the view that no single discipline could effectively tackle the complex systemic nature of medical error on surgical wards – a multidisciplinary approach was necessary to gain a more thorough understanding of these systems and healthcare processes in order to develop more appropriate products and services. DOME therefore developed a collaborative methodology to allow systems and products to be considered concurrently, paving the way for process reforms as well as new designs.

Project Overview

1

The multidisciplinary research team

The Design for Patient Safety report from the Design Council recommended that patient safety in hospitals could be improved if healthcare designers, clinicians, psychologists and business experts teamed up to tackle the problem together. This formed the basis of the DOME project's unique multidisciplinary team.

2

Involving patients and healthcare staff

The team immersed themselves in the surgical ward environment and engaged with patients and frontline staff throughout the project, gaining their trust and encouraging open conversation and shared insights. These lasting relationships allowed valuable user input into the subsequent co-design and feedback stages of the project.

3

Setting the design challenge

Through a systematic process of reviewing published literature, incident reports, observations and questionnaires, the most error-prone processes were revealed. These were crystallised into design briefs, which gave focus to the innovation phase of the project.

Generating ideas and concepts

The interaction between the multidisciplinary DOME team and the growing network of patients and healthcare staff supporting the project was a key strength in generating ideas. This phase included brainstorms, expert groups, workshops and site visits to analogous industries. Ideas were developed through sketching, computer models and prototypes, which were subjected to continuous critical feedback from patients and healthcare staff.

4

Simulation and clinical testing

Allowing end-users to try out the new designs in a simulated ward environment enabled their safety and usability to be checked. This also permitted the designs to be refined for the clinical prototypes, which are currently undergoing trials in the real healthcare environment.

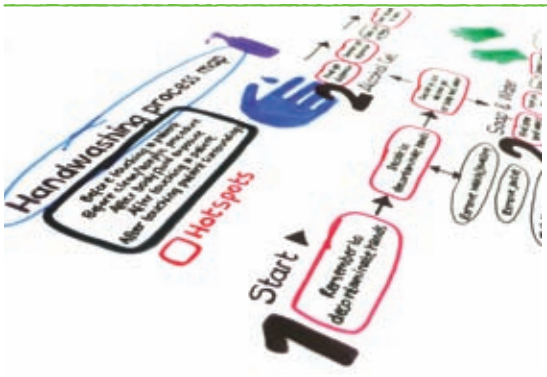
5

6

Next steps

The DOME project benefited from taking a holistic approach to designing out medical error and the design outputs are broad in range – from physical products, communication and diagnostic tools to service and environmental recommendations. Results of the project will go on show in a travelling exhibition, entitled Make It Better, in 2011/12 to solicit further feedback; clinical trials will be undertaken and key design interventions will be taken forward by manufacturers with a view to production.

Research



Mapping of the hand hygiene process

Initial observations and mapping

Members of the DOME team including designers, clinicians, psychologists and ergonomists carried out several hundred hours of initial observations in three hospitals in order to observe all activities that patients and staff participate in. Immersing themselves in the hospital environment meant they were able to investigate the full range of factors contributing to medical errors. The research team began by observing the surgical patient journey through the hospital and visualised this using mapping techniques.

Exploring the problem

Addressing every potential medical error in surgical wards was beyond the scope of the DOME project. A comprehensive literature review of all published adverse events revealed that the surgical ward was indeed as hazardous as the operating theatre, but the review did not identify the most important sources of error or explain why harm was occurring. Therefore, patients and staff participated in a risk assessment survey to determine which healthcare activities were most hazardous. The five most hazardous healthcare activities on surgical wards were identified and prioritised. Detailed observations and in-depth interviews with patients and healthcare staff allowed these five healthcare activities to be fully understood and mapped. The five highest-risk processes that occur in and around the patient's bed were hand hygiene, information hand-over, vital signs monitoring, isolation of infection and medication delivery.

A clinical group participates in a FMEA session

Observing staff and patients on a hospital ward

Prioritisation of risks

The five healthcare processes that were rated as high risk in the survey were subjected to an engineering design technique called Failure Mode and Effects Analysis (FMEA). Expert groups consisting of doctors, nurses, patients and researchers, all with experience of the subject matter, were organised by the DOME team to validate the healthcare process maps and then rate the risk associated with each step in the processes. Steps in each process that were associated with the most risk were carried forward to the next stage.

Cause analysis

The riskiest steps in each healthcare process were assessed using the framework for analysing risk and safety in clinical medicine. The expert groups were asked to give the reasons why each type of failure may occur and continue giving reasons until the systemic weaknesses of the system were identified. This allowed the causes associated with the highest risk failures in the entire surgical ward environment to be identified and targeted for patient safety improvement.

The methods used in this section are published in Anderson O; Brodie A; Vincent CA; Hanna GB. A systematic proactive risk assessment of hazards in surgical wards. Annals of Surgery. 2011. In press.

Research

Analogous industries

Concurrent with the research on surgical wards, the DOME project investigated how risk is managed and safety considered in other industries. Members of the team visited international sites in the mining, chemical, oil exploration, shipping and construction industries to draw lessons on ways to reduce systemic error. Process maps were created for analogous industry processes to sit alongside the surgical pathway maps.

Task design, reminders, equipment and space were identified as generic components in any design-led approach to improving safety. This work was combined with a review of operations management literature in the field, including key models for managing complexity such as Reason's Swiss Cheese Model (2000), which was expanded to develop a Healthcare Error Proliferation Model.

Protective clothing from the team's visit to a construction site

Arriving at design briefs

The understanding of errors, their causes and methods to manage risk was central in shaping the design briefs that would direct the eventual project results. A rich and detailed picture of where and why errors occur was built up during the research, and major systemic weaknesses became apparent. These underlying weaknesses alone, however, could not provide the basis of a design brief. It was not possible to design around a brief as broad as 'reminders' or 'equipment'; instead, this learning was combined with the original focus on healthcare processes. Each process formed the centrepiece of a brief.

Infection Control

Brief

Design a way to improve staff use of the apron and gloves for patients with a known infection, and encourage the use of alcohol hand gel.

The Problem

Staff do not always adhere to infection control rules, because the apron and gloves are not always handy, and the alcohol hand gel is easy to forget.

Insights

From spending time shadowing nurses and immersing themselves in the ward environment, the team observed that most equipment needed for patient care at the bedside was scattered all around the ward. This not only meant that common tasks took longer to complete, it also made it difficult for staff to stick to procedure as the equipment they needed was not easily accessible.

Drugs trolley with no flat surface to write on

Gel and patient's notes placed at the end of the bed

The Carestation is an all-in-one unit for the equipment needed for patient care in the bed space

The Solution

The Carestation houses all the equipment needed to care for a patient in the bed space. It contains gloves, aprons, hand gel, a medication locker, a bin, and has a flat surface for reading and writing documents.

How It Works

The Carestation is located at the end of every bed. The staff workflow is channelled past it, and the gloves, apron and gel become much more readily accessible. It also contains other items such as medication, streamlining the work and improving efficiency and compliance.

The Carestation
1 Folder holder
2 Alcohol gel
3 Flat surface for writing
4 Wipes
5 Medication locker
6 Bin
7 Apron and gloves
8 The Carestation at the end of the patient's bed

8

Hand Hygiene

Brief

Improve hand hygiene by designing a way of effectively reminding and educating staff to clean their hands at the right time, when entering and exiting the bed space.

The Problem

The role of hand hygiene in preventing the spread of infection is well known, but the lack of effective reminders means people still do not wash their hands at the right time. There is a plethora of hand hygiene reminders on the ward, mainly positioned at the entrance to wards or bays, but there is a lack of focus at the point of care – in the bed space.

Plethora of hand hygiene posters on a ward

Insights

The team visited a construction site where there was a different approach to signage. Instead of posters or homemade laminated signs, every sign was official, clear, and instantly recognisable. This insight inspired the development of a single hand hygiene symbol for use on hospital wards.

Clear safety signage on a construction site

New symbol developed for hand hygiene

A symbol for hand hygiene and a supporting campaign to encourage people to wash their hands when entering and exiting the bed space

1

The Solution

The hand hygiene symbol was developed to standardise the visual reminders on the ward; the communications campaign raises awareness and educates staff about the new initiative.

How It Works

The mirrored signs catch people's attention as it emphasises movement in the bed space. The supporting campaign uses novel ways to raise awareness, and educate staff about the new initiative.

1 Gel dispenser with new logo and introductory speech bubble
2 Promotional box of chocolates
3 Mirrored sign
4 'Wash before you cross' symbol on bedsheets

2

3

4

Design briefs

The detailed findings of the research were centred on the five most error-prone healthcare processes that occur on a typical elective surgery ward:

Infection Control – Design to support contact precautions and protocols to prevent the spread of infection

Hand Hygiene – Design to improve staff and patient compliance with hand hygiene procedures

Medication – Design to better support the typical medication administration process, particularly regarding drug omissions and nursing interruptions

Vital Signs – Design to improve the process of measuring patients' vital signs (for example, blood pressure, temperature), facilitate the recording of data and make the cleaning of equipment easier

Handover – Interventions to improve the safety of the handover of information during staff shift changes

These briefs were an important focal point in the project. In each case they were validated by a process expert to ensure that the essence of the research was captured. It was also important to inspire a breadth of creative ideas in the team. The designs on the following pages show the results of this approach.

Medication

Brief

Design a way of improving the safety of the drugs round on a ward by reducing omissions (nurses missing a drug off a patient's round) and interruptions.

Insights

The team observed medication rounds and were surprised at how many times the nurses were interrupted whilst performing such an important task. When they did get interrupted there was no safety net in place to catch an error if one occurred. If the patient was given more information and was more involved in their medication regime, it could act as a 'double check' to reduce errors.

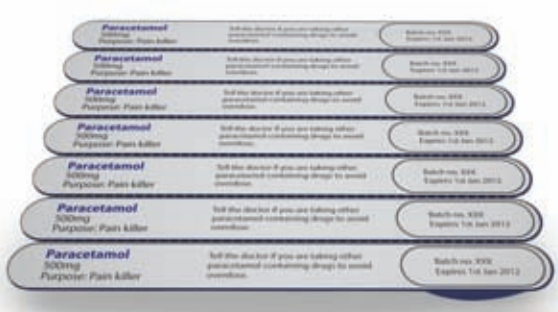
The current pill pot is lost amid bedside clutter

The Problem

Failure to administer medication can have severe consequences; missed doses, repeated doses, wrong drug or wrong strength are particular errors. It is not only the staff who are responsible – some patients refuse to take their own medication. The process is badly supported by equipment with many different systems evident, depending on the ward. Often the information about a drug becomes separated from the tablet, increasing the opportunities for error.

A nurse crouching down to deliver medication

A new way of providing patients with more information about their medication regime



1

The Solution

The medication pack has been redesigned in the shape of a spoon with patient-friendly information printed on the handle and the tablet contained in the end. Each patient has a dedicated tray to contain and display the new spoon-shaped packs. This keeps the information with the tablet right up to the point of ingestion.

4

2

3

How It Works

During a drugs round, the nurse tears off a blister 'spoon' from each pack. The various spoons are placed on the patient's tray which displays all their drugs and information for that drugs round. If a drug needs to be ordered from pharmacy, a reminder 'spoon' is placed on the tray, reminding both patient and nurse that the order still needs to be completed.

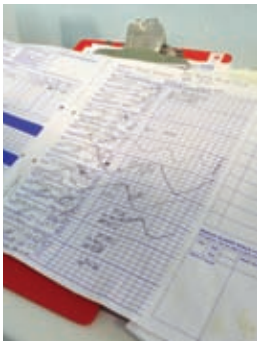
1 New blister pack design
2 Patient medication tray
3 Open pill spoons
4 Reminder spoon

Vital Signs

Brief

Redesign the way vital signs such as blood pressure and temperature are measured, making the recording of results and the cleaning of the equipment easier.

Tangled cables on a Vital Signs trolley



Complicated Vital Signs chart

The Problem

A patient's deterioration may be missed if vital signs are not measured at the right time, if they are not documented properly, and if they are not correctly interpreted. One of the most important early indicators – respiratory rate – is often not measured at all. The vital signs equipment has the potential to spread infection as it is wheeled from patient to patient; the cables are often tangled and it is difficult to clean.

Insights

From carrying out an audit of the charts the team saw that plotting was inconsistent and it was not surprising that the results were not correctly interpreted. It was clear that an electronic system would remove transcription errors. A simple redesign of the trolley introducing easy clean surfaces and a cable management solution was also necessary.

Prototyping of the new Vital Signs trolley

A trolley to monitor vital signs that is easier to clean and use – and captures and interprets data automatically

The Solution

The easy-clean design and improved cable management system of the trolley reduces the risk of infection. The new interface facilitates easy collection of results including respiratory rate, which is often overlooked, whilst the automatic plotting removes transcription errors. The trolley can dock with a larger computer on wheels.

How It Works

The screen guides the nurse through the correct procedure, captures all the data and automatically displays the figures on a chart. The screen also helps nurses to accurately measure respiratory rate, which is a crucial but often neglected vital sign. When finished, the cables are retracted back into the trolley, keeping it tidy and making it easier to clean.

The Vital Signs trolley
1 Automatic uploading of data
2 Retractable cables
3 Wipes
4 Easy clean base

Handover

Brief

Design a way to improve the accuracy and reliability of information handover between shifts.

The Problem

Handover is vital to the continuity of patient care. A successful handover needs to be supported by a well designed environment with all the necessary information at hand. It usually takes place in a room which is ill-equipped, too small and prone to interruption.

Insights

The team surveyed 50 'handover rooms' in three hospitals. This revealed that there was actually no such thing as a 'dedicated handover room' and handover usually took place in a staff room, nurses station or office.

The Solution

The design of an exemplar environment to support a safer handover. This muliti-purpose room incorporates all the necessary equipment needed for an effective handover, as well as flexible seating for up to ten nurses. When not being used for handover it provides a relaxing staff room environment.

How it works

Because space is at a premium it is not possible to have a room solely for handover. Therefore the room is designed to be flexible and has two modes: when in handover mode there is bright lighting, formal seating, writing surfaces and signage to reduce interruptions; when in staff room mode there is relaxing lighting, comfortable seating and a kitchenette for staff to take their breaks.

Nursing conducting a handover in a cramped environment

Current handover room which doubles as a staff room

The design of a flexible, multipurpose environment which facilitates handover as well as functioning as a staff room

Staff room

1 Comfortable seating
2 Kitchenette
3 Television
4 Table stowed away

Handover room

1 'Handover in process' sign
2 Kitchenette tidied away
3 Integrated software and screen
4 Fold down table for writing
5 Formal seating for 8 nurses
6 Addition folding chairs
7 Printer
8 Confidential waste bin

Conclusion

These design outputs are rooted in extensive clinical research, spanning the full three years of the project. This time span not only enabled an in-depth analysis of typical ward processes and errors, but also allowed for genuine co-design and co-research to take place.

By placing designers in the clinical environment for an extended period, and involving clinicians in the design throughout the innovation process as genuine partners, the design outputs are true to the needs of frontline hospital staff.

The five briefs were considered in parallel, in keeping with the research aim of looking at the broader context of use whenever a new design is developed. This ensured that the concepts would be fit for purpose in the complex system of a hospital ward, and also that designs such as the Carestation would incorporate features that were of benefit beyond their specific brief.

Beyond the designs, the larger lesson from the DOME research project is the benefit of time and space for a true collaborative working methodology to emerge. It is only by forging these methods of working together that the complex multidisciplinary problem of medical error can be tackled effectively.

What happens next?

The development of the DOME concepts has had the ongoing input of frontline hospital staff and patients. As the designs became more resolved, more extensive testing was carried out in a simulated ward environment at St Mary's Hospital, London. Various clinical scenarios were played out by nurses using the new designs, which were further improved as a result of feedback.

A selection of the designs will be introduced onto wards at Imperial College NHS Trust in a larger-scale clinical trial. The Carestation and an iPhone App to measure respiratory rate (part of the Vital Signs trolley design) will undergo formal trials, and results will be published as they emerge and used to improve the designs.

Manufacturers Bristol Maid (UK) and Humanscale (USA) have been involved in the development of the Carestation and Vital Signs trolley respectively, and the designs will be refined in partnership with them.

The research, methodology, designs and trial results have already been published within the team members' respective disciplines, and this work is ongoing. Dissemination of the results of the trials will occur in 2012, and it is hoped that key products will go forward to manufacture following successful trial results.

An exhibition of the DOME innovations, entitled Make It Better, will go on show at the Royal College of Art and Royal College of Surgeons Huntarian Museum in London, and in the Pontio centre for multidisciplinary design and innovation, Bangor University, North Wales.

Research Team and Advisory board

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Helen Hamlyn Centre for Design

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EPSRC
Engineering and Physical Sciences Research Council

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Organisations

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Individuals

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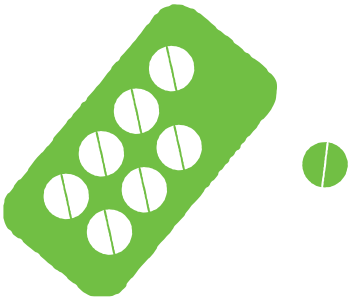
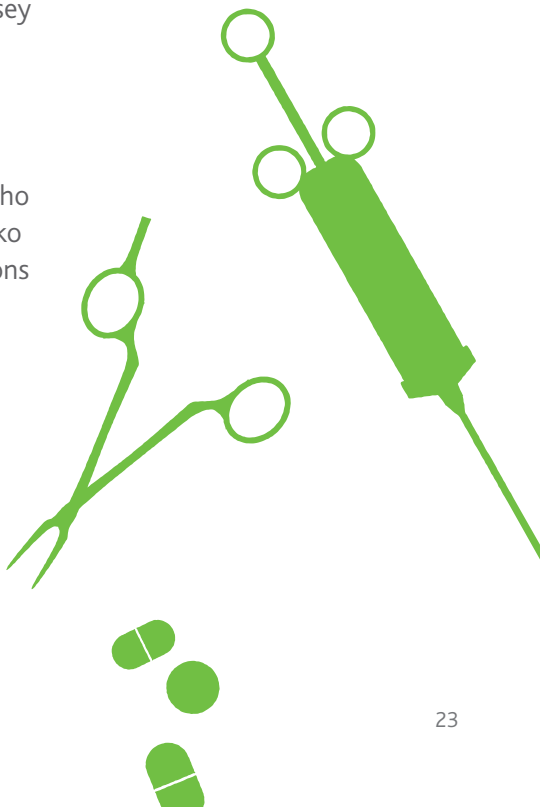
This project was completed with the help of: Chiara Bello and Emilia Serra, the exhibition designers; Daniel Becerra who completed the renderings; Maja Kecman who contributed to the design of the Vital Signs trolley; Jaakko Tuomivaara who worked on graphics and communications for the Hand Hygiene project; Peter Woods and BrainBakery Ltd who assisted in the hardware and app development; and Maureen Valfort who designed this publication.





Publications

To reflect the multidisciplinary nature of DOME, publications and presentations have been aimed at the clinical, design, management, patient safety and ergonomics/human factors communities. Selected publications include:

– Anderson O, Brodie A, Vincent CA, Hanna GB, 2011, A Systematic Proactive Risk Assessment Of Hazards In Surgical Wards, Annals of Surgery, In press.

– Anderson O, et al, 2011, Interventions to prevent healthcare bed-related injuries in patients (Protocol), Cochrane Database of Systematic Reviews.

– Davey G, West J, Anderson O, Matthews E, Myerson J, 2011, Designing Out Medical Error, (winner of 2nd best paper), Design 4 Health, 14 July, Sheffield, UK.

– Kapalis M, 2011, Improving patient safety: how to use service modularity in healthcare processes to manage systemic errors, Production and Operation Management Society, May, Reno, Nevada, USA.

– West J, Davey G, Matthews E, et al, 2011, Designing out Medical Error, World Congress for Design and Health, July, Boston.

– Anderson O, Norris B, West J, Davey G, et al, 2011, Using the systems approach to design out medical error, Healthcare Systems Ergonomics and Patient Safety, Conference Proceedings, Oviedo, Spain. Taylor & Francis Group, London.

– Kapsalis M, 2011, Patient safety and Operational Complexity: a systemic approach, European Operations Management conference, July, Cambridge, UK.

– Anderson O, Brodie A, Vincent CA, Hanna GB, 2010, An analysis of risk on general surgery wards: failure mode and effects analysis of six high-risk processes (poster), American College of Surgeons: 96th Annual Clinical Congress, May, Washington, USA.

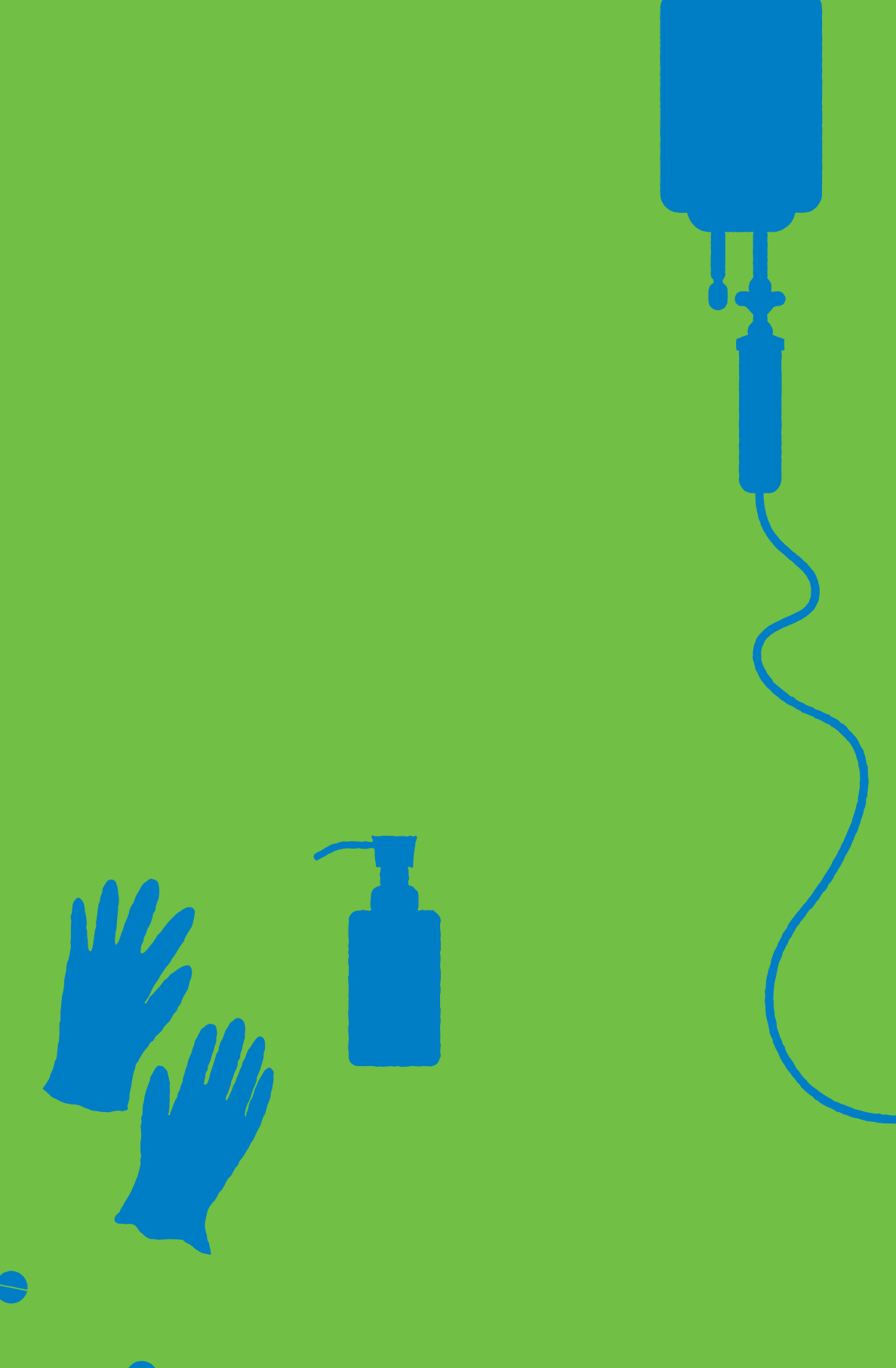
– Anderson O, Davey G, West J, et al, 2010. Identifying and prioritizing high-risk processes in elective general surgery wards (winner of prize for best research poster). 3rd North British Patient Safety Research Symposium, Nov, Bradford, UK.

– Anderson O, Davey G, West J, et al, 19 Nov 2010, Designing out preventable patient harm on general surgery wards (winner of prize for most innovative patient safety research project). 3rd North British Patient Safety Research Symposium, Nov, Bradford, UK

– Anderson O, Aggarwal R, Myerson J, 2010, Design for patient safety. International Society of Quality and Safety in Healthcare, Oct, Paris, France.

– Stanton E, 2010, 'What can we learn about patient safety from the oil industry? Patient Safety Congress, Birmingham.

See www.domeproject.org.uk for a full list of publications



DOME

Designing Out Medical Error

Mistakes made in healthcare can have huge human and financial costs. The design of much medical equipment and environments is outdated, confusing and can lead to errors.

Patient safety is a complex issue that needs approaching from different viewpoints.

The Designing Out Medical Error (DOME) project brings together a multidisciplinary team to research medical error on surgical wards and involve front line clinical staff in developing new designs.

The results are a suite of research findings and innovative designs aimed at better supporting frontline staff and reducing medical error.

EPSRC

Engineering and Physical Sciences Research Council

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Imperial College London

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