User handling studies and the design of inhalation devices

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User handling studies and the design of inhalation devices

- Terminology
- Usability – is there a problem?
- Regulatory expectations and guidance
- The design and development process
- Handling studies and where they fit
- Handling study design
- Examples
Human factors engineering (HFE) – understanding and optimising how people interact with technology

User interface – often used for computer/screen based systems (GUI) but now used more widely e.g. for medical devices

Usability – ease of use and/or safe use

Use error – results not consistent with design intent

User study, handling study, preference study, focus group – direct evaluation of defined aspects of the technology or product with representative users/customers
‘Ease of use’ and ‘user preference’ are not the same as ‘safe use’ – but they complement each other.
The Association for the Advancement of Medical Instrumentation (AAMI) sponsored a human factors conference in Washington, DC, on June 28–30, 2005.

During the conference, FDA systems engineer Peter Carstensen stated that more than one-third of medical device incidents involve use error, and more than half of device recalls for design problems involve the user interface.

These statistics prompted FDA to strengthen its initiative requiring medical manufacturers to “conduct appropriate human factors studies, analyses, and tests,” said Carstensen.
Is there a problem with usability… of inhalation devices?

Error rates for patients using *their own* device:

- Nearly one in three patients (30.9%) used DPIs ineffectively in study of 224 newly referred outpatients\(^1\)
- Failure to correctly perform essential steps for reliable lung delivery with the Aerolizer®, Turbohaler® and Diskus® was found in 17%, 23% and 24% of patients, respectively\(^2\)

Error rates for patients using *a new* device:

- % of patients with ‘critical’ handling errors after first use (reading leaflet) ranged from 25% to 72%\(^3\)
- % of patients with ‘critical’ handling errors after second use (instruction) ranged from 8% to 52%\(^3\)
- One third of subjects inhaled correctly after reading instruction leaflet\(^4\)
- 85% inhaled correctly after instruction\(^5\)

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1. Dry Powder Inhalers: Factors Associated with Device Misuse    Siegfried Wieshammer and Jens Dreyhaupt, RDD 2009
2. Inhalation technique and variables associated with misuse of conventional metered-dose inhalers and newer dry powder inhalers in experienced adults    Melani et al; Annals of allergy, asthma, and immunology., 2004
4. Comparison of the Diskus® Inhaler and the Handihaler® Regarding Preference and Ease of Use    Van Der Palen at al; Journal of Aerosol Medicine, 2007
Annex 1 93/42/EEC Essential Requirements

§ The devices must be designed and manufactured in such a way that, when used under the conditions and for the purposes intended, they will not compromise the clinical condition or the safety of patients, or the safety and health of users or, where applicable, other persons, provided that any risks which may be associated with their intended use constitute acceptable risks when weighed against the benefits to the patient and are compatible with a high level of protection of health and safety.

§ This shall include:

– reducing, as far as possible, the risk of use error due to the ergonomic features of the device and the environment in which the device is intended to be used (design for patient safety), and

– consideration of the technical knowledge, experience, education and training and where applicable the medical and physical conditions of intended users (design for lay, professional, disabled or other users).
21 CFR 820.30 Design Controls

(c) Design input. Each manufacturer shall establish and maintain procedures to ensure that the design requirements relating to a device are appropriate and address the intended use of the device, including the needs of the user and patient.

(f) Design verification. Each manufacturer shall establish and maintain procedures for verifying the device design. Design verification shall confirm that the design output meets the design input requirements.

(g) Design validation. Each manufacturer shall establish and maintain procedures for validating the device design. Design validation shall be performed under defined operating conditions on initial production units, lots, or batches, or their equivalents. Design validation shall ensure that devices conform to defined user needs and intended uses and shall include testing of production units under actual or simulated use conditions.
How do we satisfy these expectations?

EU and US regulations set expectations for Human Factors Engineering, including user/handling studies, but are not prescriptive

他们会 don’t tell us how to do it

Guides and expertise in ‘How to do it’ include

HE 75 - good methodology handbook

FDA Draft guidance – issued June 2011

Other text books and guides

Expert/consultant ergonomists

– Ideally with knowledge of the disease and its impact
FDA draft guidance

✓ Good outline of the aims, challenges and process

✓ Describes methods in some detail

✓ Is consistent with industry ‘best practice’

✓ Sets out approach to handling studies during the phases of the design process

✓ Stresses the importance of investigating ‘close calls’

✓ Provides a detailed template for the validation report and associated handling studies
Design process: circular/iterative, with a lot of testing
Device design process – iteration & testing planned within each phase
Example - GyroHaler ®

- 60 dose pre-metered DPI
- Designed to deliver a range of respiratory drugs
- >1m devices produced during development
- The next milestone is product approval
GyroHaler development path
Handling study phasing

**Total no. subjects =**
~110 patients
~100 non-patients

Concept models

- Expert appraisal
- User evaluation study
- 2nd user evaluation study
- Study with specific subjects
- Details of user interface

Moulded prototypes

- 1st PIL test
- 2nd PIL test
- Readability study
- International studies
- Home based study

Final device

- Add-on to clinical
- Preference/marketing support
- Device verification and pilot manufacture
- Clinical development/Scale up
- Marketing

Research/design input

- Concept generation & selection
- Detailed design & design proving

Time (non-linear scale)
“Formative studies can be conducted informally, with simple mock-up devices or preliminary prototypes and labelling (including the draft instructions for use), and with small numbers of test participants.”

“Modifications should be made and then evaluated … in an iterative fashion until the device is considered to be optimized to a level at which validation testing is appropriate.”

“It is particularly important during validation testing to use a production version of the device, representative device users, actual use or simulated use in an environment of appropriate realism, and to address all aspects of intended use.”

“… the test results should show no patterns of use failure or difficulties that could be eliminated or reduced through further modification of the design of the user interface.”
GyroHaler studies – detailed photographs and video

Figure 9: Operating the lever using a fingertip on the edge of the lever

Figure 10: Grasping the sides of the lever in a pinch grip
Figure 15: Inhaling with the mouthpiece cover pointing downwards – 8 subjects chose this approach.
GyroHaler studies – detailed analysis to inform the design

**Subjects confidence**

*How confident do you feel that the inhaler is ready to use?* (N=18)

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>No. of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very confident</td>
<td>11</td>
</tr>
<tr>
<td>Fairly confident</td>
<td>5</td>
</tr>
<tr>
<td>Not very confident</td>
<td>2</td>
</tr>
<tr>
<td>Not at all confident</td>
<td>0</td>
</tr>
<tr>
<td>Unsure</td>
<td>0</td>
</tr>
</tbody>
</table>

Results show that the majority of the sample were ‘very’ (11) or ‘fairly confident’ (5) that the inhaler was ready to use. Two female subjects expressed a slight lack of confidence in this respect and these were a 45 year-old inhaler user and a 24 year-old inhaler naive who both expressed similar reasons:

The inhaler user: “I suddenly thought how do I open the lever – then I saw the lip thing and it’s clear – and it opened easily – but I can see in the side chamber that I’ve not broken the blister – I heard it click – but I don’t know if it really has pierced or not”. She then concluded that it could be piercing the back of the blister.

Inhaler naive: “It clicked so it’s done some kind of action [opens side chamber] but that – the blister itself - has gone down there”

**Suggested improvements**

B3 Illustrations: It is not clear which side of the lever is being lifted. Possibly, reposition grip so that a greater area of the grip feature can be seen and take a closer view.

**Orientation of inhaler when ‘inhaling’ according to labelling option (N=22)**

<table>
<thead>
<tr>
<th>Labelling option</th>
<th>No. of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary label front (n=11)</td>
<td>6</td>
</tr>
<tr>
<td>Primary label back (n=11)</td>
<td>8</td>
</tr>
<tr>
<td>Cap up when inhaling</td>
<td>5</td>
</tr>
<tr>
<td>Cap down when inhaling</td>
<td>3</td>
</tr>
</tbody>
</table>

*Figure 12: Device orientation during inhalation*

These results suggest (bearing in mind the small numbers) that the arrangement of the hinge mechanism and cap design may exert a stronger influence on device orientation during inhalation than the location of the primary label.

Those subjects who used the device with a Primary label on the front seemed more likely to turn the device over and inhale with the mouthpiece down (5 subjects) than those who used a device with the Primary label on the back (3 subjects). This may be related to the fact that the dose counter window is more visually apparent when the device is opened with the Primary label in view and if...
End result should be a safe and appealing device

Appealing
- meets expectations
- attractive
- easy to use
- causal

Safe
- gives clear feedback
- consistent mental model
- causes no harm
- error tolerant
- gives clear feedback
- handling studies
- failure mode analysis
- consistent mental model

HFE validation report for xxx
1. Intended device users, uses, use environments, and training
2. Device user interface
3. Summary of known use problems
4. User task selection, characterization and prioritization
5. Summary of formative evaluations
6. Validation testing
7. Conclusion
   1. The xxx has been found to be reasonably safe and effective for the intended users, uses and use environments.
   2. The methods and results described in the preceding sections support this conclusion.

“... that's nice and easy...”
With thanks to:

- User Centred Solutions
- Team Consulting
- International Pharmaceutical Aerosol Consortium on Regulation and Science (IPAC-RS)
Thank you
Typical formative study

- 12-24 subjects:
  - usually patients (i.e. inhaler user)
  - sometimes selected by age/inhaler type etc.
- Broad study objective to inform design process/selection
- Should however have specific aim to identify unanticipated use-related hazards as part of risk management process
- Stimulus/test material includes concept models, usually as representative of the ‘user experience’ as possible
- Specific areas of design can be explored with greater numbers of non-patients
  - E.g. interpretation of particular features, legibility, grip etc. can be explored with larger numbers of non-patients more easily and quickly
- Inhalation manoeuvre not included
- Often includes preference aspect to address ‘do they like it?’ alongside ‘can they use it?’
Typical summative/validation study

- 12-24 subjects from each patient group
- Explicitly part of the risk management/device verification process
- Focus on robustness and safe & effective use
- Will form part of an overall picture created from clinical studies, flow rates studies, lab-based device verification testing etc.
- Legibility and comprehension of IFU also addressed
- ‘Worst case’ studies may be used to assess use and robustness in the absence of IFU and instruction
- Study materials will be final-form devices/IFU
Who are ‘representative device users’?

CHANGING SHAPE OF JAPAN’S POPULATION PYRAMID

65 years old and over | 15-64 years old | 0-14 years old

SOURCE: Statistics Bureau MIC; Ministry of Health, Labour and Welfare