Portable Oxygen Concentrators: Human Factors Concerns

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Portable Oxygen Concentrators

What are they?

- Portable Machine
- (Mostly) Pure Oxygen
- Cannulae

What for?

- Pulmonary Hypertension
- Cystic Fibrosis
- Asthma
- Chronic Bronchitis
- Emphysema
- Hypoxia
General Concerns

- Used by at patient’s home/while traveling - no physician present
- Often used by the elderly
- Portable, so needs battery indicators and has screen size limitations
- Needs to provide visual indication of flow delivery

- Display or no display? The device is fairly simple!

- How do you provide meaningful error messages with limited display capacity?

- May not be clearly visible at all times (often used on the floor, under seats, etc.)
Hazards and Tasks

- Too much oxygen = can lead to Hyperoxia
  - Portable concentrators generally can’t deliver enough oxygen to cause this

- Not enough oxygen = does not help the patient

- Limited capabilities- may not be able to match demand if breathing is fast and settings are high

- Can be a fire hazard
  - 2007 case of a mobile phone ringing and sparking when the cannula tube was removed

- Patient needs to:
  - Be able to adjust the desired flow rate
    - Physicians generally prescribe this in Liters or ML per minute
  - Know when this rate is/ is not being achieved
  - Know when the battery is running low
  - Know not to smoke/ cause sparks
Four Concentrators:

- Inogen One G1 (old)
- Inogen One G2 (new)
- Invacare Solo (old)
- Invacare XPO2 (new)
Inogen One G1

- You set an abstract ‘flow level’ instead of a rate
  - 150 ml per increment- only specified in manual!

- Lots of cannulas fit, but only single lumen works well

- Uninformative error codes: ‘1, 2, 4, 16, 128’

- ‘Mode’ button: switches ‘Breath Detection Alert Mode’ on or off
  - an alarm when no breath is detected for one minute

(why would the user even want to switch this off?)
Inogen One G2

- More appealing arrangement of buttons
- Visual coding - no labels
- ‘Mode’ button replaced by ‘Alarm’ button - same functionality, more specific
- Still unclear at a glance whether flow rate is on the low or high end
- What does ‘Setting 5’ mean?
Invacare Solo

- Provides verbose display of errors
- What are the leftward lights for?
  - Green (breath indicator), Yellow (sub-optimal operation) and Red (severe error) status Indicators (extreme graduation of error severity!)
- While errors are described textually, user may not be close to device
  - Shows flow in Liters/Min
    - Flow not always visible
- Power button oddly placed
  - Have to hold it for 3s to turn on
What is the back arrow do, exactly?

Let us consult this table:

<table>
<thead>
<tr>
<th>Action: Hold 1s</th>
<th>Normal</th>
<th>Standby</th>
<th>State: LCD Adjust</th>
<th>Mode/Flow Adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Toggle pulse/continuous modes</td>
<td>?</td>
<td>Switch columns</td>
<td>Switch highlighted item</td>
</tr>
<tr>
<td>Hold 2s</td>
<td>Switch to mode/flow screen</td>
<td>Switch to mode/flow screens</td>
<td>Save adjustments + go to normal screen</td>
<td>Save adjustments + go to normal screen</td>
</tr>
<tr>
<td>Hold 2-3s</td>
<td>Switch to LCD Adjust Screen</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
Invacare Solo

- Problems with this?
  - Case of False Simplicity
  - Unclear modes/ too many modes
    - LCD adjust is probably not needed- why not an on/off switch for the backlight?
  - Up and down arrows don’t adjust flow in all screens!
  - Selected flow rate, battery status not always available (screen flickers back and forth by default)
  - Why have a screen at all?
  - Is a yellow light something to worry about?

WARNING:

NO BREATH FOUND
Check Cannula

Triple audible beep every 10 sec
YELLOW indicator Flashing.
Invacare XPO2

- No screens/states - all information always available
- Still a button interface
- Intuitive array of flow setting lights/combined pulse indicator
- Clear ‘no smoking’ sign

- Battery gauge next to battery
  - ‘Battery Status Button’
  - Turns this gauge on - why would you want it off?
- Fewer ways of coding errors; simpler, but less detail
- When there is no breath detected, a constant audible alarm sounds and the red light illuminates
Trends & Conclusions

- Get rid of modes!
- Cut out toggle switches and options that the user has no reason to use
- Display crucial information all at once, if there isn’t that much of it; don’t hide things in alternate screens
- Place display elements and controls in accordance with mental models
  - Why not use a physical dial? There aren’t that many flow levels!
- Displays are not always necessary, especially when they would have to be extremely small
- Clearly indicate spark/ fire hazards- not just smoking that is a problem
- When possible, visually communicate qualitative notions of ‘low’ and ‘high’; an arbitrary numerical setting with no units is not informative.
  - In addition, allow flow to be set in the units that were prescribed
- Alarms should be informative, but also behaviorally meaningful- the user should know whether or not to take action
  - HF Issue: do we want to display alerts or diagnostic info?
  - Should these be error states, represented by status indicators, or more like warning messages?
  - Is it worth adding complexity to inform the user specifically what is wrong, when only a few things could be wrong?


Thanks!