Supplementary file 4. Usability violations of the ROI tool detected from the thinking aloud procedure and heuristic evaluation

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| **Usability principle** | **Usability problems** | **Severity score** | **Think aloud** | **Heuristic evaluation** |
| 1. Visibility of system status | Are there any incidents where the ROI tool is unresponsive or slow? If so, please list them and indicate how severe they are. |  |  |  |
| * The tool as a whole performs too slow for a stakeholder (especially at the beginning) | 2 | X |  |
|  | * It is too much time to get results | 2 | X |  |
|  | * Sometimes when clicking on a button or on an option, the system is not immediately responding, making one wonder whether one clicked on the correct place in the interface | 1.8 |  | X |
|  | * While running the analysis, progress seems to be fixed at 10%, while one expects that the tool will keep adding percentages to 100. | 1.4 | X | X |
|  | * The animations in demographics are a bit slow and seem unnecessary without indicating whether it is finished. | 1.4 |  | X |
|  | * The analysis takes more than 60 seconds on my computer; the indication of the time might be slightly modified. | 1.2 |  | X |
| 1. Match between system and the real world | Are there any strange words/sentences used in the tool? If so, please list them and indicate how severe they are. |  |  |  |
| * Some input data (e.g. uptake or cost of interventions) are not country-specific. For Netherlands, usually estimates used are from 15 plus instead of 16 plus. | 3.2 | X |  |
| * Confusing terms or some terms not clear | 2.8 | X |  |
| * Difficulties with the meaningfulness of the cut-down to quit intervention, better explanation needed | 2.6 | X |  |
| * Excessive use of abbreviations make it difficult to understand what is displayed on the screen (Results) | 2.6 | X |  |
| * Formulation of text not clear, missing logical connectedness, e.g. regarding the persons who make a quit attempt | 2.4 | X |  |
| * The sentences are too long and the ends of phrases could not be seen in some cases (e.g. The y-as of the graph doesn’t provide the full title at the benefit-cost analysis). | 2.4 | X |  |
| * It is not clear what increasing/decreasing the cost per person does. An expert felt doing something wrong when a red cross appeared when changing something. | 2.2 |  | X |
| * Unclear why social marketing was initially indicated as red | 2.2 |  | X |
| * Provide a Narrative Report in layman’s terms (Narrative Report). | 2.2 | X |  |
| * It is weird that when one does not select a interventions, it says: “The investment of 0 in top-level interventions results in more smokers planning to make a quit attempt in the next year”. | 2 |  | X |
| * Commas and points should be switched | 2 | X |  |
|  | * The button named “ok” is not evident. It would be better to name it as “next” (for Hungary). | 1.8 | X |  |
|  | * Rounded numbers more convincing (trustworthy) than the used exact numbers implying an accuracy not possible | 1.6 | X |  |
|  | * Lay out is too old-fashioned (e.g. the main hyperlinks are in caps lock) | 0.8 | X |  |
| 1. User control and freedom | Are there any instances where important changes cannot be easily undone? If so, please list them and indicate how severe they are. |  |  |  |
| * Narrative report provides the wrong estimates (generation of the report goes wrong) | 4 | X | X |
| * Discount rate and threshold cannot be modified correctly. | 3.6 | X |  |
| * It is too intricate to find the different types of the results. The button of the indicators (BCA, ABD, ICER, NPV) is not evident. | 3.4 | X |  |
| * Details of certain interventions could not be found easily , not intuitive (e.g. telephone support) | 3.2 | X |  |
| * Changing the values of parameters: sometimes not possible (errors), sometimes too little steps when clicking on “+” and “-“, recognizing that figures could be filled into the fields by Keypad | 3.2 | X |  |
| * Users sometimes feel uncertain where to go next. | 2.8 | X |  |
| * Interventions could not be found easily (takes too many clicks through other sections of the tool, users get impatient) | 2.8 | X |  |
| * Adding 40 000 euros of investments to an intervention result in inconsistent information in the tool at the top left: 40 002 (alternative investment column) | 2.8 | X |  |
| * Not always clear how to get back to previous screen (e.g. from intervention details to intervention oversight) | 2.6 | X |  |
| * There is no back button in some slides (e.g. back to interventions, and back from results, page before the analysis, slide with percentage of smokers) | 2.2 | X |  |
| * One is not able to enlarge the screen of the tool | 1.2 | X |  |
| 1. Consistency and standards | Are there any inconsistencies concerning language use or functionality? If so, please list them and indicate how severe they are. |  |  |  |
| * Problems with the understanding of the structure of the tool, not clear what the three buttons represent (they should be placed next to its description) | 3.4 | X |  |
| * For Hungary: the tool does not classify each intervention to the right group. (e.g. top-level interventions were classified to the pharmacotherapy group) | 3.2 | X |  |
| * The logic of the tool is difficult to understand at first use. | 3.2 | X |  |
| * Difficulties in finding the real analysis part of the tool | 3.2 | X |  |
| * It is not clear for the users that the packages of the interventions are compared with each other. (The users think that one intervention can be compared with another.) | 3.2 | X |  |
| * The button to go back to the overview from the individual interventions was not clear. | 3 |  | X |
| * You can see when an intervention is Dominant, but not the corresponding figure of savings (Results). | 3 | X |  |
| * Terminology in part not uniform (it would be better to use precise and consistent usage, combinations of words, e.g. cost-benefit ratio vs. benefit-cost ratio). | 3 | X |  |
| * Proceeding often only via trial and error | 2.8 | X |  |
| * Sensitivity analysis are missing in the tool | 2.8 | X |  |
| * Too complex and not understandable for a non-economist (especially in the results section). | 2.8 | X |  |
| * “Save” button could not be found where the user would like to record a new intervention. | 2.6 | X | X |
| * When fiddling with the interventions on/off to see what it does to the number of smokers planning to quit, the percentage in the figure changes, but the old percentage also remains visible, therefore I cannot read it properly. | 2.6 |  | X |
| * It would be useful to show the analysis from the National Health System perspective, separated from the quasi-societal perspective (Results/Narrative Report). | 2.6 | X |  |
| * Buttons don’t look clickable, hyperlinks should be more clear and provide feedback to the cursor. | 2.6 | X | X |
| * The numbers and rates of smokers and quitters are not clear. They are too complicated. It is hard to follow them. (on pages of Demographics and Interventions) | 2.6 | X |  |
| * The titles ‘chart’ and ‘table’ on the upper left side of the right side if the screen do not update correctly in the results. | 2.4 |  | X |
| * There is need to be able to print/export the graphics | 2.4 | X |  |
| * The navigation of the tool is not self-evident and unequivocal. | 2.4 | X |  |
| * Incremental costs and health benefits (LY gained, QALYs gained) should appear clearly when the tools shows Cost-Effectiveness Analysis results (Results). | 2.2 | X |  |
| * “confirm your population information” does not seem -to match with “top-level interventions to encourage quit attempts | 2 |  | X |
|  | * The combinations of interventions is missing (pharmacotherapy and counseling) | 2 | X |  |
|  | * Percentage of current smokers in the population is showed in a counter intuitive way. It should indicate the percentage of current smokers who do not smoke daily. | 2 | X |  |
|  | The display of estimates in the graph is unclear (one does not notice that this estimates appears when the cursor moves over it) | 2 | X | X |
|  | * Difficulties viewing changes over different time horizons. There should be the option to view results over different time horizons in one figure. It is wearisome having to change the time horizon continuously (Results). | 2 | X |  |
|  | * It shows former smokers before current smokers, that is counter intuitive (Demographics). | 1.8 | X |  |
|  | * The menu at the start should mention included regions only | 1.6 |  | X |
|  | * The tool being regarded as complex depends heavily on the type of user of the tool | 1.6 | X |  |
|  | * The tool is inconsistent with the lay out and navigation of websites (slide down hyperlinks) | 1.4 | X |  |
|  | * Placement of numbers | 1 | X |  |
|  | * It would have been interesting for one stakeholder to have the possibility to select subgroups of the population for the analysis | 1 | X |  |
| 1. Error prevention | Are there any instances where you made or could make mistakes? Before executing an action, were you asked for confirmation where needed? If so, please list them and indicate how severe they are. |  |  |  |
| * Sometimes interviewees want to leave the results section and to perform some analyses elsewhere in the tool, although the analysis would have to be performed within the results section. Results may imply an end-state after an analysis and changing something may imply that the analysis needs to be redone. | 3.2 | X | X |
| * Settings and results of the analysis should be saved within the tool, e.g. such that unintended loss of calculation results by leaving the results section is avoided | 3 | X |  |
| * When exploring effects of the pro-active telephone support intervention, users exclude other interventions | 2.6 | X |  |
| * Difficulties to know at what time to do calculations or at what time simply clicking on intervention names suffices in order to find the answer to a certain problem | 2.6 | X |  |
| * Difficulties in using the tool if the user belongs to an older generation, especially regarding technical problems that could appear | 1.6 | X |  |
| * Try to leave an intervention page using the Excel-cross at the top right corner of the window leads to a closure of the whole tool instead of leaving only a certain part of the tool | 1.6 | X |  |
| 1. Recognition rather than recall | Are there any pages where the content or structure is unclear or insufficiently explained? If so, please list them and indicate how severe they are. |  |  |  |
| * The mechanism of the three packages was not (fully) understood, especially when and where to calculate an alternative package and what exactly the baseline package means | 3.4 | X |  |
| * It is not clear that the users have to run the model to get the results (Change from Interventions to Results). | 3.2 | X |  |
| * More detailed definition is needed to distinguish between interventions aimed at the whole smoking population and interventions targeted at smokers who are making quit attempts (Interventions). | 3 | X |  |
| * Uncertain and unclear how to add the investment | 3 | X | X |
| * It is unclear which numbers are suitable to be changed by the user. There should be some hints/warnings if scientific based values were changed | 2.8 |  | X |
| * It is not clear in the details of each intervention, what intervention is placed previously and next | 2.8 |  | X |
| * It was not clear who is responsible to change the population information (whether all users are allowed to do that) | 2.8 |  | X |
| * Details and sources of parameters within the tool are not visible (e.g. year of the data) | 2.8 | X |  |
| * It is unclear what the number of smokers ready to quit was before selecting an additional (top-level) intervention to invest in. | 2.6 |  | X |
| * There is a need for more detailed description on interventions included | 2.6 | X |  |
| * The parameters right before the results section, especially QALY threshold, is not explained such that the user doesn’t know what should be chosen in a certain desired situation | 2.4 | X | X |
| * It would be more clear if all of the top-level interventions could be visible (list all of them). | 2.2 | X |  |
| * The number of expected/potential quitters unclear for each intervention | 2 | X |  |
| * It would facilitate using the tool if the 3 main menu points (demographics, interventions and results) could be visible permanently. It would be easier to change them. | 2 | X |  |
| * It is easy to miss the initial percentage of smokers when going forward on the screens (Demographics/Interventions). | 1.8 | X |  |
|  | * The purpose of the first slides are unclear (it should state that one must confirm their population estimates, and that the estimate represents the whole adult population) | 1.8 | X |  |
|  | * It would lead to better structuring if the three groups of interventions could be visible on independent pages, one after another | 1.8 | X |  |
|  | * Not so much self-explaining at the beginning; within the results section it seems to be more self-explaining | 1.8 | X |  |
|  | * To see the results in terms healthcare costs/savings is necessary to export the Narrative Report, it should be displayed on the screen (Results). | 1.8 | X |  |
|  | * It is not clear why one needs to select a region (in order to have region specific estimates in the ROI tool) | 1.4 | X |  |
|  | * Date of the last modification of the tool is not visible | 1.4 | X |  |
|  | * The source “Eurobarometer” not used within the tool | 0.4 | X |  |
| 1. Flexibility and efficiency of use | Are there any frequently used functionalities that are not accessible fast enough? If so, please list them and indicate how severe they are. |  |  |  |
| * Output-menu, blue menu (in opened form) within results section is not visible the whole time, difficult to find in closed form | 2.8 | X |  |
| * Problem recognising the view change possibility (table vs. chart) | 2.4 | X | X |
| * Knowing about possibilities of the tool is difficult | 2.4 | X |  |
| * Difficult to recognize that a click on the intervention name would facilitate to fill in an additional investment | 2.4 | X |  |
| * Too many clicks are needed to get to the right page of the tool, especially when the stakeholder goes through the model step by step | 2.2 | X |  |
| * There is a lack of a search button in the tool. (e.g. It would be easier to find an intervention in the tool.) | 1.8 | X |  |
|  | * Other non-economic aspects are not considered (e.g. ethical) | 0.8 | X |  |
| 1. Aesthetic and minimalist design | Are there any instances in which the tool offers too much information? Is there an instance in which you lost track of the situation? If so, please list them and indicate how severe they are. |  |  |  |
| * Sometimes it is not clear to which absolute number a figure in percent relates to | 3 | X |  |
| * Too much information in the tool, therefore confusing | 2.2 | X | X |
| * Too much information within the narrative report, overextension | 2.2 | X |  |
| * Inappropriate colors of the figures. The colors of the figures are too similar and figures should look more impressive. Some graphics in the results section are very saturated. This makes them difficult to interpret (Results). | 1.6 | X |  |
|  | * The data changing in the tool could be indicated by a switch of the color. | 1.2 | X |  |
|  | * The color of the frame of the alerts could be differentiated by the type of message | 1.2 | X |  |
|  | * The total population (the pink title) should be placed above the graphic | 1 | X |  |
| 1. Help users recognize, diagnose, and recover from errors | Are there any error alerts which were not clear or which did not identify the problem correctly or did not provide a solution? If so, please list them and indicate how severe they are. |  |  |  |
| * Some runtime errors appeared, tool crashed several times, especially when some estimates in the results section were changed, added a new intervention, selected a region, or generating the narrative report | 4 | X | X |
| * No solutions were provided in the error alerts | 3.4 | X |  |
|  | * Tool could not be applied during interview due to use of a Mac by the stakeholder. Interview was either cancelled or performed on a new date with the stakeholder being at home | 2.4 | X |  |
| 1. Help and documentation | Is there enough help or documentation available? If so, please list them and indicate how severe they are. |  |  |  |
| * Help buttons didn’t provide any information | 3.2 | X | X |
| * Need of a glossary to understand the tool faster and better, lack of some definitions, e.g. quasi-societal, reach, and uptake | 3 | X |  |
| * There is not enough help available in the tool. It would be good if the definitions of the interventions, the calculations of the cost of interventions, and the source of the data appear. | 3 | X |  |
| * Navigation guide of the tool is missing, content after analysis is unclear. | 2.8 | X | X |
| * The pop-up windows explaining that you can view intervention details by clicking on the intervention name seems to be not recognized fully | 2.6 | X |  |
|  | * Need of help icons providing access to assumptions of the model | 2.4 | X | X |
|  | * The possibility of pushing the red cross to reset its setting is not clear. | 2.2 | X |  |
|  | * It would be good if a short interpretation of the results could appear when the users click on one of the results. | 2.2 | X |  |

Severity score: 0-0.9 cosmetic problem, 1-1.9 minor usability problem, 2-2.9 major usability problem, 3-4 usability catastrophe