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Reference range number line format preferred by adults for display of asthma control status

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ABSTRACT

Objective: Optimal asthma self-management requires an accurate understanding of one's asthma control status. Tailored infographics are a promising way of conveying status information but little is known about which formats are effective at supporting comprehension while also being appealing to adults with asthma.

Methods: In this focus group study, we compared two formats to display Asthma Control Questionnaire (ACQ) scores: a stoplight graphic and a reference range number line (RRNL).

Results: Both formats supported comprehension but the RRNL was strongly preferred for its informativeness and for cueing participants to consider the self-management strategies they should undertake to improve their asthma control.

Conclusions: The RRNL format may have broad appeal and can be adapted to numerous clinical variables for low health literacy patient-facing displays, as in patient portals. However, until viewers are familiar with the format, use as a communication tool in the context of a clinical visit is recommended to forestall undue alarm over abnormal/out-of-range values.

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Introduction

Patients with asthma need an accurate understanding of their current level of asthma control in order to engage in effective health self-management and shared decision making regarding treatment. However, low health literacy (LHL) may be a barrier to adequate comprehension of measures of asthma control and the implications of the resulting scores [1]. LHL, which is common among the same vulnerable populations as those with increased asthma risk [2], is associated, along with limited English proficiency (LEP), with elevated rates of uncontrolled asthma [3]. Indeed, LHL has been shown to be an impediment to achieving proficiency at important asthma self-management skills including proper inhaler technique [3,4], peak flow monitoring, and asthma action plan use [5,6]. Self-management begins with an understanding of the rationale for the self-management actions needed to achieve optimal health outcomes. Therefore, one possible mechanism linking LHL and LEP with inadequate self-management is a lack of comprehension of asthma control status. While many studies report the association between asthma control, LHL and LEP [1,3,7–11]

strategies to improve comprehension of asthma control status are understudied. Comprehension of asthma control status is of particular concern among socially disadvantaged groups because they have a greater prevalence of asthma, disproportionate asthma disease burden, lower asthma numeracy skill, and higher rates of medication non-adherence [7,12].

Tailored information visualizations—customized by computer to display data specific to the viewer—have been proposed as a means of comprehension support [13,14]. However, best practices with respect to optimal visualization formats are still emerging. Additionally, little is known about whether or not formats vary in acceptability and appeal between demographic groups. In this study, we focused on two formats: a reference range number line (RRNL) and a stoplight graphic (see Figure 1).

Recent studies of RRNLs have examined the effects of variations to RRNL formats on comprehension of clinical values (e.g., blood glucose, platelet count) among patients [14] as well the level of urgency perceived by viewers when presented with out-of-range results [15]. Stoplight graphics have been studied for a wide variety of purposes, including promoting

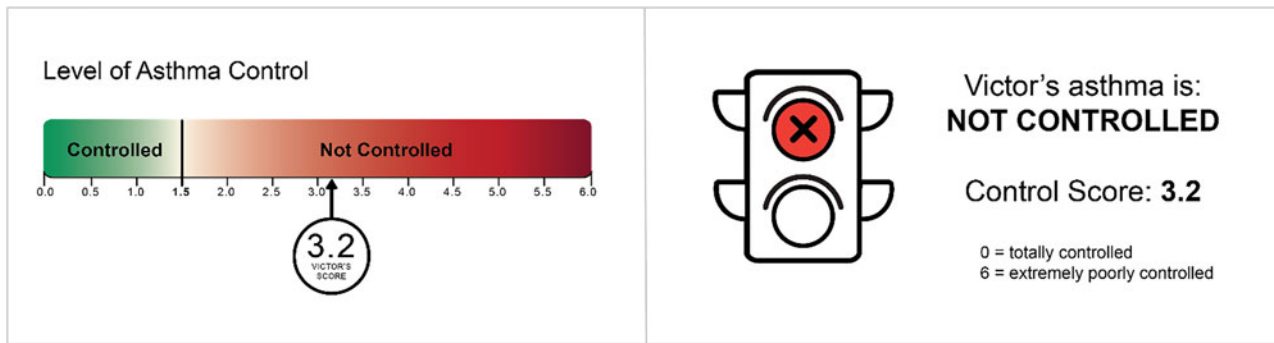


Figure 1. Asthma control status displayed using two formats: reference range number line (RRNL) at left; stoplight graphic at right.

avoidance of sugary drinks [16], eliciting self-ratings of blood-alcohol level [17], showing an individual's blood pressure [13], and depicting levels of caregiver burden [18]. Stoplight imagery might be particularly salient to patients with asthma because asthma action plans almost uniformly use a stoplight to convey steps to take when asthma is well-controlled (green light indicates “good to go”), when asthma is not well-controlled (yellow light indicates “slow down”), and when asthma is very poorly controlled (red light indicates a medical emergency).

We know of two studies that directly compared the RRNL and stoplight graphic formats [13,19]. Both studies examined the cultural appropriateness of the formats among urban Hispanics. Results were consistent in that participants in both studies presented the same design challenge: they desired high information density yet demanded that designs remain simple. However, participants differed in the two studies in that the stoplight design was more universally endorsed as a means of displaying a blood glucose forecast [19] whereas the RRNL was the clear favorite to display blood pressure [13]. Desai and colleagues speculated that owing to the speed and urgency with which a high blood glucose value must be addressed (compared to blood pressure), the stoplight graphic was more contextually appropriate than the RRNL [19].

Asthma control

A key approach to assessing and monitoring asthma is through the use of validated measurement instruments. Three measures recommended for such use by national asthma guidelines [20] are the Asthma Therapy Assessment Questionnaire (ATAQ) [21], Asthma Control Test (ACT) [22], and Asthma Control Questionnaire (ACQ) [23,24]. All are based on self-report of symptoms; the ACQ also includes an

optional item incorporating the results of pulmonary function testing. Each measure yields a numerical score that is then compared to reference ranges that indicate whether or not the patient's asthma is controlled. For example, when used for research purposes, ACQ scores between 0 and 1.5 suggest asthma is well controlled, whereas scores between 1.5 and 6 indicate uncontrolled asthma; in clinical practice, the more conservative cutpoint of 0.75 is used to differentiate between controlled and uncontrolled [24]. The prototype infographic designs developed for this study were based on the ACQ, using the cutpoint associated with research (i.e., 1.5). The research literature does not provide guidance for which visualization formats may be best to display asthma control status.

Our goal is to improve asthma control among socially disadvantaged adults by encouraging medication adherence. As such, we envisioned the use of an asthma control report to serve as a communication tool between clinician and patient during a primary care office visit. Therefore, the purpose of this focus group study was to evaluate the acceptability and appeal of the two graphical formats for display of asthma control status in a sample of urban African American adults with asthma receiving services at a Federally Qualified Health Center (FQHC) as well as their loved ones. The images used in this study were early prototype designs; the results of the study were applied to subsequent refinement of the preferred format. Discussion of the designs occurred within the context of a larger focus group study that sought to adapt an evidence-based brief shared decision-making/motivational interviewing intervention to address medication non-adherence in African American adults with uncontrolled asthma in primary care.

Methods

This focus group study was approved by the institutional review boards of Columbia University Medical

Center and the University of Pennsylvania. Recruitment and data collection took place at two FQHCs providing comprehensive primary and preventative care in Philadelphia. Inclusion requirements were the same as that of the larger study: participants had to be adults (18 or older), self-identify as Black or African American, and be either a patient with persistent asthma (defined as having been prescribed a daily inhaled corticosteroid), or the loved one (self-identifying as any race/ethnicity) of a patient with persistent asthma. At intake, patient participants were administered the ACQ (used with permission) as a measure of their asthma control [23,24], and both patients and their loved ones completed the Newest Vital Sign (NVS) as a measure of health literacy [25]. ACQ data were not shared with the participants due to concern that it would influence their responses to the focus group questions.

The stimuli for the focus group discussions were two preliminary prototype designs of tailored infographics displaying the ACQ score of a fictitious patient, Victor. The two formats presented in the designs were a RRNL, shown at left in Figure 1, and a stoplight graphic, shown at right in Figure 1. The green and red gradients in the RRNL were selected specifically so that they would be distinguishable from one another under various color blindness conditions. The stoplight is presented with only two lights (i.e., no yellow) because there are only two result categories for the ACQ: controlled and uncontrolled. The prototype designs were described to participants as something that would be shown to them by their care provider in the context of an office visit. During the groups, preference between formats was recorded by voice or hand vote.

An expert in qualitative methods (MG) led the focus groups using an approved semi-structured interview guide that was informed by qualitative descriptive methodology and is summarized in Table 1. Sessions were audio recorded and professionally transcribed. An experienced coder (AA) performed conventional content analysis [26] aided by standard word processing software. The coder used a coding

structure determined *a priori* according to the interview guide prompts as shown in Table 1. For example, for prompt #1 “What information do you think we are trying to convey with this image? What does it mean to you?” code 1 was used to identify any and all participant interpretations of the meaning of the stimulus infographic, even if the interpretation was given in the context of another question. Next the information captured by each code was synthesized and distilled to characterize the breadth of opinions associated with the code as well as the prevailing sentiment, if a consensus emerged among the participants. The analysis was reviewed by the focus group leader (MG) and the results were discussed until consensus was achieved.

Results

Groups

Six focus groups were held in April and May of 2017. Sessions lasted about 60 to 90 min each, with an average of 15 min (range 10–22) devoted to discussion of the prototype designs. Overall, 46 participants attended the six groups with group size ranging from 2 to 10.

Participants

All participants were African American (with one reporting more than one race and one reporting their ethnicity as Latino) and native English-speakers, two-thirds were women, nearly three quarters had marginal or inadequate health literacy, and of those with asthma, 78% had uncontrolled asthma as measured by the six-item ACQ (without pulmonary function results) (see Table 2). Participants’ verbatim quotations are presented in double quotes throughout this section.

Meaning

For both formats, participants readily identified the intended message that Victor’s asthma was uncontrolled. A few participants put forth explanations for

Table 1. Focus group guide prompts and associated foci of coding for analysis.

Focus group guide prompt		Analytic focus
1.	“What information do you think we are trying to convey with this image? What does it mean to you?”	Viewer perception of infographic meaning
2.	“Which of the images do you prefer and why?”	Statements of preference
3.	“How can the image be improved?”	Suggestions for potential design changes
4.	“Would this image motivate you to address the health issue?”	Statements relating to (a)motivation or health self-management
5.	“How much and what kind of information do you want?”	Sentiments about quantity, timing, and type of informational reports

Table 2. Participant characteristics ($N = 46$).

Characteristic	<i>n</i>	(%)
Gender		
Female	31	(67)
Male	15	(33)
Race		
African American/Black	45	(98)
More than one race	1	(2)
Ethnicity		
Non-Hispanic	45	(98)
Hispanic	1	(2)
Type		
Patients, controlled asthma	7	(15)
Patients, uncontrolled asthma	25	(54)
Loved ones	14	(30)
Health Literacy Level		
Inadequate	13	(28)
Marginal	20	(44)
Adequate	13	(28)
	<i>M</i>	<i>(SD)</i>
Age	47	11.3

the cause of his status (“This shows that he is not taking his medicine as he should”) and others projected the consequences of his status (“He’s on his way to having his lungs shut down!”).

There was some variability in how participants reacted to the different formats. The spotlight format evoked severe perceptions of threat: “He’s not getting no (*sic*) oxygen in his lungs,” “He’s in great danger,” “You really need to go to the hospital.” The X inside the red light was seen as especially indicative of danger and death (“With the X, it’s over. I’m checking out. It’s over!”) but perceptions that Victor’s condition was very serious persisted even when participants were shown a version of the spotlight without the X. Participants saw the spotlight as precluding change (“It’s just like stage four cancer. There’s nothing else to do.”). By contrast, with the RRNL, participants recognized the potential for change (“He can either continue his bad habits and probably make it worse or you know, he’s got to do what he’s got to do to fix it.”)

Although all the participants came to the same conclusion that Victor’s asthma was uncontrolled, there were three instances in which participants made statements suggesting potential for misinterpretation present in the RRNL format, especially for unequal reference ranges. In one instance, two participants appeared to focus more on the intensity of the color gradient than on the black line indicating the cutpoint between categories at 1.5 (“2.0 and below would be good and everything above is a problem”). In another instance, one participant implied that Victor’s result could be inferred by the size of the reference range (“...because the ‘control’ part is much less ... and the ‘not controlled’ is a much larger margin”). In the last

instance, two participants cued in to the position of Victor’s score in the middle of the number line (“It looks sort of half and half”) which could lead to under- or overestimations of severity depending upon the location of the cutpoint(s) in a given RRNL.

Preference

All but two participants preferred the RRNL to the spotlight graphic, citing its greater informativeness. Whereas the spotlight only shows the controlled/uncontrolled category labels, the RRNL allows the viewer to see the range of values associated with each category label. As such, participants preferred the RRNL because it gives a linear, visual representation of where a value falls within a range and, if uncontrolled, how far that value is from the goal. Participants’ preference was driven in part by the motivational value of being able to visually track progress towards a goal:

*“When you first get the scale, if it’s over here in the red, as you (*sic*) progressing, if you’re taking your medicine and doing what you’re supposed to do, then you’ll notice it start to get close to the green and it makes you feel more like ‘I’m doing my job,’ you would feel more ... yes, it would motivate you better.”*

“It’s a scale. You can see where you are and where you need to get to.”

-Two participants, Group 4

Self-management

When asked to consider how they would react if given the same result as Victor, participants volunteered

statements that indicated that they perceived a threat (“I’m in danger of losing my life”) and that they would undertake self-management actions in response. Frequently cited actions included avoiding asthma triggers (“I try to stay away from perfume”), taking medication, and following up with their health care provider (“I would be asking the doctor what other treatments are available because—especially if I know that I’m taking it daily like I’m supposed to and they handed me something like this—it’s not working”).

Design changes

The only suggestion for improvement offered by participants was the inclusion of additional information about how to improve their asthma control. For example, one participant thought the RRNL could have been better “if they would’ve had something on there that tells you how you can control it.”

Reports

Participants were satisfied with the amount of information presented in the number line (“It’s just right, actually”). The consensus was that they would like to see this type of tailored infographic report at the beginning of every visit: “So that way we could discuss what we’re going to do to correct it.” One participant suggested making an informational poster to put up in the examination room: “Stuff like this should be on the wall so that you can see and know so that you can ask. Like my daughter is diabetic so every time we go, even before they get to say what her [hemoglobin] A1c level, that was our first question, ‘what’s the A1c level?’.”

Discussion

Both the RRNL and spotlight graphic were perceived as easy to understand but the RRNL was overwhelmingly preferred because of its greater motivational value and informativeness. The ability to see a result in the context of reference ranges supports interpretation of the value and, if the result is out of a desirable range, distance from the goal. The importance of information density is consistent with a recent study of variations on the RRNL format [14] as well as with our prior work with Hispanics [13]. Given its acceptability among both Hispanics and African Americans, it seems likely that the RRNL format has broad appeal. This finding is important because RRNLs are already being incorporated into patient-facing portals

[27]. In our current study, we have discontinued the spotlight graphic and continued refinement designs using the RRNL format to display ACQ scores. The RRNL format can easily be adapted to display scores for other measures of asthma control (i.e., ATAQ or ACT) as well.

Despite the general ease of interpretation displayed by participants, there are still opportunities for misinterpretation, particularly because of the asymmetry of the reference ranges. Some viewers may underestimate the severity of middling values because they are making a judgment based on the “placement of test results in a visual space of possible values” [15] and giving insufficient consideration to color and labeling cues. This effect could be exacerbated even further if the clinical (0.75) rather than research (1.5) cutpoint is used [24]. In our subsequent refinement of infographic designs that use the RRNL format, we have focused on incorporating additional cues to support correct interpretation, chiefly interpretive statements (e.g., “Your asthma is not in control”) and illustrations anchoring the endpoints of the scale (e.g., smiling figure vs. figure having difficulty breathing).

As demonstrated by Zikmund-Fisher and colleagues [15], specific design features can influence the level of health threat perceived by the viewer. For example, Tao et al. found that increasing amounts of information led to increased perceptions of risk [14]. Reactions to the RRNL were not as dramatic as to the spotlight, but the intensity of threat perception was still high. We conceived of this infographic specifically as a tool to facilitate communication between clinician and client during an in-person interaction. Therefore, the potential for undue alarm evident in participants’ reactions reaffirmed our belief that a patient’s initial viewing of a novel tailored infographic may best be mediated by a clinician who can put the threat in the context of the patient’s larger clinical picture as well as engage the patient in shared decision making about appropriate next steps. In situations where it is infeasible to have a clinician mediate the initial interaction with a tailored infographic, additional strategies may be used to aid in guiding the viewer’s reaction. For example, Woollen [28] and Morrow et al. [29] have explored the use of computerized relational agents to suggest to the viewer the appropriate level of concern about the information provided. However, given how context-dependent risk can be, we propose that a personal interaction is preferable until the viewer is familiar with a specific infographic. The spotlight graphic may still be useful, as Desai et al. speculated

[19], to indicate urgency in situations in which additional subtleties of meaning are not required.

Compared to the stoplight graphic, the RRNL format was particularly effective at cueing viewers to consider appropriate preventive actions including adherence to medication regimens and avoidance of triggers. As such, participants' suggestion of adding tailored tips for improved asthma control is apropos and should be implemented. In this way, the infographic not only draws attention to the disease threat, but also suggests ways to reduce that threat. When used as a clinician-patient communication tool, as we propose, the clinician can present the tailored infographic at the beginning of every visit having populated the asthma control tips prior to printing/display, or write them in based on the result of shared decision making. The RRNL prototype design shown in Figure 1 has been incorporated into a study evaluating a brief shared decision-making/motivational interviewing intervention to address medication non-adherence [30]. We encourage interested parties to contact us about reuse of our infographics in both research and clinical settings. Although our study was limited to displaying asthma control status, it is easy to see the applicability of this type of communication tool for a wide variety of clinical variables.

This study shares the limitations inherent to focus group studies such as the potential for undue influence by outspoken participants. Also, participants' reactions to simulated data for a fictitious person are an imperfect proxy for the results of real world implementation. As such, we are currently conducting a comprehension and acceptability study in which participants with asthma are presented with refined infographics tailored with their own data. Additional studies will be needed to evaluate implementation in the clinical setting and the extent to which tailored infographics influence actual patient behaviors.

Conclusion

Acceptability and preference of graphical formats is driven by adequate information density and promotion of the message that health status can improve through self-management. The RRNL format achieves these goals and may be appropriate for many different patient-facing displays. Infographics are an engaging and appealing way to raise awareness of disease risks and cue desired health-promoting behaviors. Ideally, tailored infographics to show asthma control status are presented in the context of a clinical visit

and are accompanied by specific suggestions for self-management.

Declaration of interest

The corresponding author serves as an advisor to Astra Zeneca and on Advisory Board to Teva. The coauthor reports no conflicts of interest.

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