Enhancing adherence to quality-of-care guidelines for colorectal cancer patients using the Rasch model

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ABSTRACT

The aim of this study was to enhance adherence to quality-of-care guidelines for colorectal cancer (CRC) patients. Rasch analysis using Winsteps 3.8 was performed to examine the undimensionality of the 13 core indicators. An author-made Excel model was applied to plot a Wright map and KIDMAP to report physicians’ adherence to the quality-of-life guidelines. It was found that the scale of the quality-of-care guidelines for patients with colon cancer is unidimensional. A total of 34 (8.6%) and 20 (5%) persons’ response patterns (i.e., Outfit MNSQs >2.0 and 4.0, respectively) are aberrant and dispersed from the majority of the sample according to their estimated parameters of persons and indicators. It can be used to investigate the root cause of the low measures and/or aberrant pattern of responses through the Rasch Wright map and KIDMAP once any one indicator of unexpectedly aberrant treatment (p<0.05) presents. Many indicators are excluded from the calculation of adherence rates due to disease stage, cancer type and the reasonable discontinuation of treatment etc. The Rasch model can address these binary and/or missing data. It is hope that this paper contributes to ensuring that hospitals adhere to the treatment guidelines for patients with colon cancer.

Keywords: Colorectal cancer, Rasch model, unidimensionality, KIDMAP, Wright map.

INTRODUCTION

Colorectal cancer (CRC) is a malignant neoplasm arising from the lining of the large intestine (colon and rectum). It is the third most common cancer in males and the second in females (Akhatar et al., 2014). In 2009, the estimated new cases of colon cancer and rectal cancer in the United States were 106,100 and 40,870, respectively (Le et al., 2014). In 2013, approximately 40,340 new cases of rectal cancer were diagnosed in the United States (Siegel et al., 2013). Australia, New Zealand, Canada, the United States and parts of Europe have the highest incidence rates, whereas China, India, parts of Africa and South America have the lowest risk of colorectal cancer in the world (Jemal et al., 2011). CRC is the third leading cause of cancer-related death worldwide, with over 900,000 diagnoses and 639,000 deaths each year (Leon-Carlyle et al., 2009).

Overall, sixty per cent of these CRC patients present with stage II or III disease, which recurs with metastatic or locally invasive disease in approximately 35–40% of patients (Arends, 2010; Jonsson et al., 2010). Treatment for CRC varies by tumor location and stage at diagnosis. The surgical removal of the tumor and nearby lymph nodes is the most common treatment for early stage (Stage I or II) colorectal cancer (Akhatar et al., 2014). Patients with late-stage disease are often treated with chemotherapy alone or in combination with radiation therapy before or after surgery (Akhatar et al., 2014). In spite of this, the survival rate for colorectal cancer varies with stage of disease at diagnosis and typically varies from 90% for cancers detected at the localized stage to 10% for distant metastatic cancer (Jemal et al., 2004; Steele et al., 2014).

Considering patient quality of life, many studies (Chien et al., 2012; Chung et al., 2008; Mandelblatt et al., 1999; Malin
Table 1. Indicators available for use.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Colon cancer</th>
<th>Rectal cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clinical stage should be reported before surgery</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Colonoscopy was done 6 months before and 3 months after surgery</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>3</td>
<td>Histopathology reported degree of involvement of surgical margins &amp; number of lymph nodes for patients with stage I–III CRC</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>4</td>
<td>Patients with stage I–III CRC were at negative margin status</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Pathological tumor &amp; node stage should be reported after surgery</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>6</td>
<td>12 or more lymph nodes were examined in patients with stage I–III CRC</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>7</td>
<td>Pathology reports were checked</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>8</td>
<td>Patients with COLON stage III were offered surgery within 6 weeks after C/T</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>9</td>
<td>Patients with stage I–III CRC were treated within 6 weeks</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>10</td>
<td>Patients with stage I–III CRC were offered surgery within 16 weeks after CCRT</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>11</td>
<td>Treatments were performed within 6 months following 6 months after surgery for newly diagnosed cancer patients with stage I–III CRC</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>12</td>
<td>Colonoscopy or LGI was performed 2 years after surgery</td>
<td>X X X X X X</td>
<td>X X X X X X</td>
</tr>
</tbody>
</table>

Note. X denotes exclusion of indicator by stage, cancer type and the reasonable discontinuation of treatment, i.e., patients not eligible for the specific procedure.

et al., 2000; Spencer et al., 2003;) have claimed that physician adherence to quality-of-care indicators improves cancer patients' treatment outcomes. A means of plotting novel and objective graphical representations that are not limited to bubble charts (Chien et al., 2012) is required to help monitor physician performance, which improves the rate of adherence to quality-of-care guidelines for CRC patients.

MATERIALS AND METHODS

The study sample included 708 patients with newly diagnosed colorectal cancer who had been treated between 2004 and 2007 at a 1,300-bed hospital in southern Taiwan. Data from these patients' charts were obtained and approved by the Research Ethics Review Board of the Chi-Mei Medical Center (registry no C6218) (Chien et al., 2012).

A set of 13 core measures was used to assess adherence to the quality-of-care guidelines for patients with CRC. The 100% adherence rate criterion contributed to a relatively low hazard ratio of 0.36 (95% confidence interval, 0.14-0.85; P = 0.02). The association between the adherence rate and survival indicated significant improvements for Stage III patients compared with Stage I patients. Three hundred and ninety-seven patients with colon cancer were extracted from the sample of 708 patients (Higashi et al., 2005). Each indicator assigned to each cancer stage was dichotomously coded (Table 1). Physician adherence to core indicators was assessed using the Rasch model (Rasch, 2960).

Rasch analysis

An inherent weakness of conventional analytical techniques based on classic test theory (CTT), such as the summation of all item scores, is that they require linear, interval scale data input (Wright, 2997). Raw data collected through a dichotomous scale (e.g., 0 for fail and 1 for success in Tables 1 and 2) are always ordinal because their categories indicate the ordering without any proportional levels of meaning (Wright, 2997; Bond & Fox, 2007). Therefore, it is highly possible to obtain misleading conclusions when applying CTT to raw scores, which are ordinal data by nature.

The Rasch model overcomes this problem by converting ordinal data into interval measures, which have a constant interval interpretation and provide objective measurement
of dichotomous (0 vs. 1) responses (Linacre, 2015). Once the interval metric is established, person measures and item difficulties are calibrated onto a single unidimensional latent trait (i.e., the level of the quality of care in this study) scale, which facilitates direct comparisons between person measures and item difficulties (Figure 1). Empirically, Rasch analysis has been successfully applied in education and social sciences to address assessment issues (Bond and Fox, 2007; Panayides et al., 2010; Tormakangas, 2011).

Rasch person fit statistics have also been frequently used in the academic fields of education and psychometric research (Sijtsma and Molenaar, 2002; Linacre, 2015; Li, and Olejnik, 1997). Table 2 shows typical dichotomous patterns. According to the estimated parameters of persons and items, the two mean square errors (MNSQs) of Infit and Outfit for each person can display significantly aberrant behaviours (different from others; this result requires further investigation) once the MNSQ is greater than 2.0 (Linacre and Wright, 1994; Linacre, 2002), for instance, person 3 with an Outfit MNSQ 3.91 in Table 2 shows an aberrant abnormality. Furthermore, the Rasch model can address missing data (Fisher, 1995; Ludlow and O'Leary, 1999), such as the symbol X shown in Table 1 and the dot responses in Table 2, which are problematic in CTT approaches (Montiel-Overall, 2006; Moulton, 2015; Peugh and Enders, 2004).

**Rasch model's Wright map and KIDMAP**

In Rasch analysis, the term "item map", "variable map", or "Wright map" is often used to describe the representation of items and persons on the same continuum (Wilson, 2011; Rittle-Johnson et al., 2011). It is acknowledged that Ben Wright of Chicago University had championed this approach to interpreting the results of measurement analyses in the form of between items and persons.

KIDMAP, a personal performance sheet that takes the form of within a person related to items, is developed within the context of Rasch measurement and usually used to display academic performance in schools (Wright et al., 1980; Chien et al., 2009a; Chien et al., 2009b). Four quadrants were used: harder indicator not achieved (i.e., under expectation when the response score is less than the expected value on the respective indicators), harder indicators achieved, easier indicators not achieved, and easier indicators achieved. Accordingly, respondent errors (with a significant dispersion apart from the expected value) that require more attention are plotted on the bottom right quadrant, indicating easier indicators not achieved. A complete KIDMAP highlights the level at which a patient's care meets (or not adhere to) the quality guidelines and pinpoints the strengths and weaknesses of the evaluated doctor's performance (Doig, 1990; Masters, 1994).

**Table 2. A comparison of adherence indexes for individual response patterns.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Person Responses:</th>
<th>Easy -- Items -- Hard Infit</th>
<th>Outfit Measure</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modelled/Ideal</td>
<td>1110110110100000 0.66</td>
<td>0.55 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>2</td>
<td>Guttman/Deterministic</td>
<td>1111111110000000 0.68</td>
<td>0.57 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>3</td>
<td>Miscode</td>
<td>0000000001111111 2.73</td>
<td>3.91 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>4</td>
<td>Carelessness/Sleeping</td>
<td>0111111110000000 0.81</td>
<td>0.83 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>5</td>
<td>Lucky Guessing</td>
<td>1111111000000001 0.87</td>
<td>0.85 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>6</td>
<td>Response set/Miskey</td>
<td>1010101010101010 1.26</td>
<td>1.26 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>7</td>
<td>Special knowledge</td>
<td>1111000011110000 1.02</td>
<td>0.88 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>8</td>
<td>Imputed outliers</td>
<td>1111010110101000 0.86</td>
<td>0.74 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>9</td>
<td>Low discrimination</td>
<td>1110101010101000 0.83</td>
<td>0.70 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>10</td>
<td>High discrimination</td>
<td>1111101101000000 0.83</td>
<td>0.70 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>11</td>
<td>Very high discrimination</td>
<td>1111111101000000 0.53</td>
<td>0.45 -0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>12</td>
<td>With missing data</td>
<td>.111 .111 .100 .11</td>
<td>0.99 1.86</td>
<td>0.83</td>
</tr>
<tr>
<td>13</td>
<td>With missing data</td>
<td>111 .111 .111 .10</td>
<td>0.49 2.02</td>
<td>0.89</td>
</tr>
<tr>
<td>14</td>
<td>With missing data</td>
<td>000 .000 .111 .0</td>
<td>1.55 0.72</td>
<td>0.75</td>
</tr>
<tr>
<td>15</td>
<td>With missing data</td>
<td>11.1 .00 .00 .000 .0</td>
<td>0.60 -1.12</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Note. The dot ("." ) refers to a response with a missing datum. SE denotes the standard error of the respective person measure.
guidelines using Wright map and KIDMAP.

RESULTS

The Wright map displayed in Figure 1 shows that all indicators on the right side are dispersed rather well (within the criterion of Infit MNSQ between 0.5 and 1.5), supporting a one-dimensional measurement of the quality-of-care guidelines for patients with colon cancer.

In Rasch analysis, the mean of indicators’ difficulties is arbitrarily set to zero logit (i.e., in a unit of log odds, the far most left vertical values in Figure 1), and the interpretation of indicator difficulties and person measures are based on pair-wise comparisons between indicators and persons. Therefore, person measures higher than zero indicate a positive response, while person measures lower than zero indicates a negative response. Figure 1 shows that only 14 persons’ measures (=14/397=3.5%) are less than zero, indicating that a few persons received care that was below the quality-of-care guidelines. The reasons for this low quality of care must be further investigated.

A patient report card using scatter chart plots of individuals’ coordinates with their Outfits and measures is shown in Figure 2. A total of 34 (8.6%) and 20 (5%) persons’ response patterns (i.e. Outfit MNSQs >2.0 and 4.0, respectively (Linacre, 2014) are aberrant and dispersed from the majority of the sample according to their estimated parameters of persons and indicators. The reasons for this result must be further investigated as well.

A person whose Outfit MNSQ is higher (=3.63) than the criterion (>2.0 [Linacre, 2014]) is illustrated in Figure 3. It can been seen that indicator 12 (with a response of 0, as shown in parentheses) is located on the right side bottom, indicating that indicator 12 (i.e. treatments were performed within the 6 months following the first 6 months after surgery for newly diagnosed cancer patients with stage I–III CRC) is easy but not achieved (i.e., coded as 0). The most unexpected indicator with a caret (^) symbol according to the function{=\frac{\text{observed} - \text{expected}}{\text{SD}}=(0-0.96)/0.2= -4.8 > t \text{ test criterion at 1.96, whereas } 0.96 = \frac{\text{EXP}(2.12-(-1.2))}{(1+\text{EXP}(2.12-(-1.2)))} \text{ is the probability to code as 1,}}
Figure 2. Patient report card using a scatter chart to plot individuals’ coordinates with their Outfits and measures.

and −1.2 is the indicator difficulty) displays a statistically significant abnormality against others’ performance when the person’s quality of care value is 2.12 logits.

DISCUSSION

We found that the scale of the quality-of-care guidelines for patients with colon cancer is unidimensional. A total of 34 (8.6%) and 20 (5%) persons’ response patterns (i.e., Outfit MNSQs >2.0 and 4.0, respectively) are aberrant and dispersed from the majority of the sample according to their estimated parameters of persons and indicators. It can be used to investigate the root cause of the low measures and/or aberrant pattern of responses through the Rasch Wright map and KIDMAP.

Using a set of 13 quality indicators for the assessment of the quality of cancer patient care, a strong association between physician adherence rates to quality-of-care indicators and colorectal cancer patient survival was found (Chien et al., 2012; Cheng et al., 2009), which complies with previous reports (Cheng et al., 2009; Higashi et al., 2005). It is evident that improving adherence rates will also improve the quality management of cancer health care (Williams et al., 2005). Accordingly, we programmed an Excel-based module to present patients’ quality-of-care guideline measure and Outfit MNSQ on a scatter chart (Figure 1), followed by plots of between items and persons (Figure 2) and within a person related to indicators (Figure 3). Interested readers are welcome to request the module for practice and use. We think that (1) the module can help cancer treatment teams improve their adherence rates and (2) other hospitals should report Wright map and KIDMAP together for continuous CRC quality-of-care improvement.

Such a graphical demonstration of results is much more useful than the bubble charts used to check performances (Chien et al., 2012) and the previously published papers that did not present any effective ways, such as fit statistics shown in Figures 2 and 3, to improve adherence to quality-of-care guidelines (Higashi et al., 2005; Chung et al., 2010).

More than 80% of medical resources are under physician control (Ekkenburg, 1994; Evans et al., 2013). One way to change physicians’ behaviour is to offer them comparable information (Ekkenburg, 1994). We ensure that this visual representation allows us to attain the rule of ‘always comparing and improving quality of care’ at the physician level through the feedback reporting process (Chien et al., 2009a; Chien et al., 2009b), which exists to motivate
Figure 3. The most unexpected indicator with a caret (\(^\wedge\)) symbol shown by the guideline adherence level.

physicians to more closely adhere to the quality-of-care indicators. For simplicity, we only drew 397 patients with colon cancer from the sample of 708 patients (Chien et al., 2012). The unidimensional scoring scale cannot be generalized to patients with rectal cancer. When the plotting of a Wright map and KIDMAP is applied to any other cancer patients, the preliminary approach of examining and verifying the scale's unidimensionality should be conducted. Another limitation is the need to offer members of cancer treatment teams training to interpret the Wright map and KIDMAP correctly.

Empirically, Rasch analysis has been successfully applied in education and social sciences to address assessment issues (Bond and Fox, 2007; Panayides et al., 2010; ommakangas, 2011). In clinical practice, many indicators are excluded from the calculation of adherence rates due to issues such as stage, cancer type and the reasonable discontinuation of treatment, i.e., patients not eligible for the specific procedure. The Rasch model is suitable and appropriate for addressing this type of binary (i.e., 1 and 0) and/or missing data, and easily used in Microsoft excel. We hope that this paper contributes to ensuring that hospitals adhere to the quality-of-care treatment guidelines for CRC patients.

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REFERENCES


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