A dashboard online on Google Maps showing inpatient perception of hospitalization experience across the US 52 states

Abstract

Background: The quality of health care is always an important topic we concern in the medical settings. There are many ways to report healthcare quality to the public. However, those professional indicators are unfamiliar to patients when using a static table or image format which is hard to know where to get the best care.

Objective: This study is to visualize survey results about inpatients’ perceptions of patients’ hospitalization experience of states in the US using Google Maps.

Methods: We downloaded HCAHPS (Hospital Consumer Assessment of Healthcare Providers and Services) data from the 2007-2014 summaries of survey results. The data collection was carried out to (1) show the significant improvement point over the years using the method of Hotelling’s T-square paired sample and present the trends for each domain about service improvement on Google maps, (2) display online dashboards to show hospitalization satisfaction for each US state on Google Maps, and (3) demonstrate an online assessment that uses smartphones for gathering perceptions of their hospitalization experience.

Results: The year of the inflection point for service improvement is at 2013. The
domain of Discharge Information makes a significant improvement in performance over the years. A visual dashboard shows on Google Maps for understanding inpatients’ perceptions of hospitalization experience of states in the US. A smartphone APP was designed to get feedback directly from patients.

**Conclusions:** We demonstrated a dynamic reporting of patient hospitalization experiences across 50 US states on Google Maps, which is superior to the traditional report card with a static table or image format. The visual feedback to patient responses can be promptly displayed on Google Maps. The HCAHPS can improve the report card of the patient hospitalization experience in the future.

**Key words:** Google map, report card, HCAHPS, hospitalized experience perception, Hotelling's T-square paired sample

**Highlights**

• We verified that the improvement point o is at 2013.

• The domain of Discharge Information makes a significant improvement.

• A dashboard on Google maps successfully reports inpatient perception on hospitalization experience across US 52 states.

• A smartphone APP was designed to get feedback directly from patients.

Running Title: Google maps and patient perception on hospitalization in the US

Abstract word Count: 228

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**Introduction**
The quality of health care is always an important topic we concern in the medical settings, especially in the age that the patient involvement is appearing increasingly on the policy and action agendas of health care providers [1]. There are many ways to report healthcare quality to the public. However, those professional indicators are unfamiliar to patients when using a static table or image format which is hard to know where to get the best care [2-6].

The England Picker Institute Europe (EPIE) [7] and the Hospital Consumer Assessment of Healthcare Providers and Services (HCAHPS) [8] are two famous examples of periodically assessing patient expectations of hospital healthcare, experience, and satisfaction, and of publicly reporting their perceptions of their experience and whether they were satisfied [9-11]. From which, Picker’s item-by-item box plots of disclosure and the HCAHPS hospital characteristics comparison charts are the addition to the summary analysis page on their respective web sites. Whether a dashboard-type report card can be used for releasing survey results is required to develop.

Google Maps provide an overall view of geospatial visualization with coordinates of latitude and longitude on a map [11,12]. However, few were found in Medline library using keyword google map in the title to search on June 12, 2018. An easy way with application programming interface (API) [13] technique to help hospital practitioners quickly set up an assessment system for patient quality of health
Further, the HCAHPS survey consists of eight domains in comparison each year for the same states in the US. The scenario of multivariate cases is similar to evaluate both Year A and Year B based on indicators, and to see if there was a significant difference between the two years which is suitable for applying One Sample Hotelling’s $T^2$ Statistic for analyzing data[14].

The aim of the current study was thus to investigate (1) whether the inpatients’ perceptions of patients’ hospitalization experience of states in the US have been significantly improved, (2) what type of API that can help us quickly build up an online method for displaying survey results on Google Maps, and (3) how to demonstrate an online assessment that uses smartphones for gathering patients’ perceptions of their hospitalization experience.

**Methods**

**Study Data**

We downloaded data (Summary Analysis of HCAHPS survey results: January 2007 to December 2014) Discharges of inpatient perceptions of their hospitalization experience across 52 US states (includes Washington, DC, and the territory of the United States Virgin Islands) at the HCAHPS website [8]. The freely available spreadsheet there includes 10 dimension scores (range: 0-100 [higher is better]) consisting of the following: (1) Communication with Nurses, (2) Communication with

**Task 1: Trends in each domain across years using Hotelling’s $T^2$ Statistic**

Paired samples occur in some different situations. Pairs of similar individuals (or states in this study) are selected in such a way that the two members of each pair are more similar to one another than they are different observations in the dataset. Under this setting, for a single sample of individuals (or state), measurements may be taken both before and after treatment (survey). The multivariate case using Hotelling’s $T^2$ Statistic suitable for those many indicators in a survey is very similar to the univariate case using paired t-test[14].

We compared CMS surveys across years using Hotelling’s T-Square to ensure the year of the inflection point in hospitalization service improvement. The darker color denotes, the higher value in a table to clarify the interpretation of the data by using visual representations.

**Task 2: A dashboard on Google maps to show the survey results**

An online dashboard was designed to report patient perceptions of the inpatient hospitalization experience on Google Maps. The trends for each domain across years (from 2007 to 2014) were on Google Maps.
The Gini coefficient (CC) \cite{15} is used for calculating the inequality of quality-of-care service for each state in the US: the higher, the Gini; the more inequality is. A Gini index value above 0.40 is considered high \cite{16,17}. A Gini index value of 30 or above is considered medium. A Gini index value lower than 30 is considered low \cite{18}.

The Gini equation can be shown by the following formula, where $X_i$ = the score for each domain, $X-bar$ = mean of the domain scores and $q$ = the number of bins (i.e., the number of domains). The numerator denotes the total absolute deviation between scores in bins. The denominator represents the maximal portion of the total difference.

$$
Gini = \frac{q}{q-1} \times \frac{\sum \sum |X_i - X_j|}{2 \sum \sum \bar{X}_{ij}} = \frac{q}{q-1} \times \frac{\sum \sum |X_i - X_j|}{2 \times q^2 \times \bar{X}}$$

(1)

**Task 3: An online assessment using smartphones**

An online app was designed for patients to report their perceptions of their inpatient hospitalization experience. The HCAHPS 25-item questionnaire (see Additional file 1) was used in the app. Four questions were designed to automatically select different paths after they have been answered. For example, if a patient responds “No” to question 10 (During this hospital stay, did you need help from nurses or other hospital staff to get to the bathroom or to use a bedpan?), the app will skip questioning 12, but it will go on to question 11 if the patient answers “Yes”. This means that the app will consecutively check each question’s response and respond accordingly, which will make the app more convenient and practical to use.
Results

Task 1: Trends in each domain across years using Hotelling’s $T^2$ Statistic

Trends in each domain over the years show in Figure 1. As can be seen, all domain scores increased from 2007 to 2014. The easier domains with, the higher scores are Discharge Information, Communication with Doctors, and Communication with Nurses. The most difficult domains with the lower scores are Overall Hospital Rating, Quietness of the Hospital Environment, and Communication about Medicines. Interested readers are suggested to see the results on Google Maps as reported in the reference [19]. The year of the inflection point for service improvement is at 2013, see Table 1, which is easy to discriminate by using the Hotelling’s $T^2$ Statistic in Table 1.

![Figure 1 Trends of each domain across years](image)

![Table 1 Comparisons of CMS surveys across years using Hotelling’s T-Square](image)
### A. T-square and F statistics

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<thead>
<tr>
<th>Year</th>
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<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
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<td>106.58</td>
<td>335.3</td>
<td>479.87</td>
<td>732.16</td>
<td>1568.5</td>
<td>7493.3</td>
<td>10176.</td>
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<tr>
<td>F</td>
<td>2007</td>
<td>8.73</td>
<td>282.07</td>
<td>627.24</td>
<td>1508.6</td>
<td>2000.3</td>
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<td></td>
<td>2008</td>
<td>6.87</td>
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<td></td>
<td>2009</td>
<td>27.49</td>
<td>22.13</td>
<td>1106.3</td>
<td>9369.0</td>
<td>12766.</td>
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<tr>
<td></td>
<td>2010</td>
<td>39.34</td>
<td>51.43</td>
<td>18.22</td>
<td>632.98</td>
<td>768.33</td>
<td>9450.5</td>
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<td></td>
<td>2011</td>
<td>60.03</td>
<td>123.71</td>
<td>48.21</td>
<td>51.9</td>
<td>300.17</td>
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<td>2012</td>
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<td>24.61</td>
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<td>749.34</td>
<td>768.26</td>
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<td>778.76</td>
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<td>V-values</td>
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<td>1</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>11</td>
<td>9</td>
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### B. No difference on domains between years

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Note. (i) Hotelling’s T-Squares between years are in the upper triangle, (ii) V-values are in the lower triangle (the darker, the higher value), and (iii) domains with the number without difference between years are in the bottom panel.

Task 2: A dashboard on Google maps to show the survey results
A dashboard on inpatients’ perceptions of hospitalization across 2007 to 2014 for the 50 US states is shown in Figure 2; the icon on the year at the right-hand bottom can be clicked to change the presentation [19]. The Picker’s item-by-item box plot is illustrated by the state of Washington 2008 (GC=0.05), as shown in Figure 3. This can be obtained by clicking the bubble of the US state being studied, see the upper-left pannel in Figure 2.

We can see that in Figure 3, the highest score for WA is Discharge Information (83) and the lowest is Quietness of the Hospital Environment (50). The GC 0.05 indicates an extremely equality among domain scores in 2008.

From Figure 3, we can also see that the most difficult domain (i.e., with the least mean score = 64) is Q5 (Communication About Medicines). The easiest ones (i.e., with the highest mean score = 86) are Q2 (Communication with Doctors) and Q8 (Discharge Information) with a mean of 85. To see the details about any specific US state, interested readers are suggested to click the link through the reference [19] on Google Maps using the zoom-in and zoom-out functions.
for the US 50 states sized by Gini coefficients, clicking the icon on the year to change the dashboard.

![Picker’s item-by-item box plots for Washington in 2008](image)

**Figure 3** Picker’s item-by-item box plots for Washington in 2008

**Task 3: An online assessment using smart phones**

After scanning a QR-code shown in Figure 4, we can directly assess the inpatient hospitalization experience on the HCAHPS 25-item questionnaire by smart phones. In which, four questions will immediately redirect to the next specific questions according to the answer response. The respondents are easily confused when encountering the skip question in a paper-based survey. We demonstrated an interactive prompt module for gathering feedback about hospitalization experience from patients. The visual resulting representation can be seen instantly after
completing the survey response. The interpretation of Figure 5 is similar to that of Figure 3.

Figure 4 A snapshot of a visual representation for the feedback to the patient survey response on a smartphone.
Discussion

After analyzing the data of inpatient hospitalized experience perception downloaded from HCAH, we (1) confirmed the hospitalization service has been continuously improved through years and the infection point at 2013, (2) presented a visual representation of dashboard that can compare performance score on Google maps for showing the stable(or instable) healthcare cluster of US states, (3) demonstrated an API module that can be used merely by clicking the APP. A video is
at the Additional file 2 and 3.

There were many surveys about patient experience in the hospital. Most of them were administered by postal mail, and response rates varied widely, from very low to relatively high [20]. The US HCAHPS 2013 survey showed the average response rate was 32% [8]. The first public report was in 2008. By contrast, the England NHS led the way internationally in mandating a national patient survey program in 2001[21].

The Picker Institute [7] has a number of survey tools targeted towards patient experience, for use both within and outside hospitals. An increasing number of people are using the Internet as a platform to describe their healthcare in the UK [22]. Similarly, in the US, more than eight out of 10 adults are using the Internet regularly [23]. Furthermore, smart phones are becoming ubiquitous [24-25]. It is time to develop a module that can show the survey results on Google Maps. The reason is attributable not only to the study [21-26] reporting the web-based online ratings correlated well with the traditional national survey and had similar response rates but also to the very solicited survey of patient experience feedback sent by the hospital. It may be useful tools for patients who responded the survey in a hope to see the results with a visualized representation. However, no such a convenient tool (i.e., using Google maps) was found to show and compare the performance of inpatient perception of hospitalization in previous papers.
Another finding is regarding the trends of all dimension scores. A positive increasing improvement across years shows in Figure 1, which is never seen before about HCAHPS survey of inpatient perception in hospitalization. One picture is worth ten thousand words. We hope following studies can report other types of study results to readers in future using Google map API.

There are several limitations to this study. First, the data were extracted from the HCAHPS website, see Additional File 4. It is worth noting that any generalization should be made in the similar feature based on the healthcare service and the period being investigated. More studies are required to verify the quality of care provided by US states in the future. Second, we downloaded study data from a website for the scores (from 0 to 100) of HCAHPS survey which were not the original responses from patients. Future studies are recommended to use the first-hand data from patients if possible to yield the more precise results about the inpatient experience of hospitalization to maintain the whole information in the analysis. Third, a dashboard is not limited to the one we provided in Figures. Many others are needed to develop on the internet in the future.

Conclusions

A novel module designed by authors was demonstrated and used for reporting data to responses about their hospitalization experience. We reported the performance of US state about patient satisfaction. It is possible for the data of patient experience feedback to be collected using the most online approaches and giving patients a really
clear idea of where to get the best care through the animation dashboard on Google Maps.

**List of abbreviation**

API: application programming interface

CC: correlation coefficient

EPIE: The England Picker Institute Europe

GC: Gini Coefficient

HCAHPS: Hospital Consumer Assessment of Healthcare Providers and Services

VBA: visual basic for application

**Additional files**

**Additional file 1:**

PDF. The US HCAHPS inpatient experience questionnaire

**Additional file 2:**

MP4. The online responding survey and feedback of visual representations to the respondents
http://www.healthup.org.tw/marketing/course/marketing/HCAHOS2014B.mp4

Additional file 3:

MP4. The briefing of this study

http://www.healthup.org.tw/marketing/course/marketing/GoogleHCAHPS.mp4

Additional file 4:

Xls. The study dataset

**Author contributions**

TWC developed the study concept and design. SY and TWC analyzed and interpreted the data. WC monitored the process of this study and helped in responding to the reviewers’ advice and comments. TWC drafted the manuscript, and all authors provided critical revisions for important intellectual content. The study was supervised by WC. All authors read and approved the final manuscript.

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