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KAKENHI

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研究課題名（和文）Concept Design and Implementation of Personalized Triage to Reduce Healthcare Data Errors in Human Assisted Remote Healthcare Systems

研究課題名（英文）Concept Design and Implementation of Personalized Triage to Reduce Healthcare Data Errors in Human Assisted Remote Healthcare Systems

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研究成果の概要（和文）：リモートヘルスケアデータには、通常の臨床データよりも多くのエラーが含まれています。 エラーのほとんどは、医療従事者による人間の入力エラーが原因で発生します。 本研究では、統計的な手法を持ち、Human Acceptance Range（HAR）、GroupAcceptance（GAR）および個人受け入れ範囲（PAR）の概念を導入し、エラーの発生率を削減することができました。
GARを評価するために、バングラデシュに４回実験を行い、患者から999の医療データを収集しました。　主な観察結果は、エラー率がすべての場合で0.00％であり、異常なデータが4.23％に減少したことです。

研究成果の学術的意義や社会的意義
Detecting and reducing errors in remote healthcare systems has been a challenge. The findings of this research are expected to improve the efficiency of remote healthcare systems. This improved approach will help increase the efficiency of remote healthcare systems and also reduce cost and time.

研究成果の概要（英文）：Remote healthcare data carries more errors than usual clinical data. Most of the errors occur due to the human input errors by the healthcare workers. We came up with a solution to predict three different acceptance ranges- (a) for a particular community (b) for an age group and gender and (c) for a particular person, we call them Human Acceptance Range (HAR), Group Acceptance Range (GAR) and Personal Acceptance Range (PAR).
To evaluate GAR, we prepared an experimental field in Bangladesh. By organizing PHC service campaign (four times) we gathered 999 healthcare data from similar patients. The 1st phase found 1.62% unusual and 0.00% error data. The 2nd phase found 1.00% unusual and 0.00% error data. The 3rd phase found 1.00% unusual and 0.00% error data. The 4th phase found 1.63% unusual and 0.00% error data. A major observation is that the error rate was 0.00% in every case and unusual data was reduced to 4.23%.

研究分野：情報通信技術

キーワード：remote healthcare　portable health clinic　error detection

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１．研究開始当初の背景

Our **Portable Health Clinic** project (32 locations in Bangladesh) has archived **39,549 health records** in the last 7 years. The system generates erroneous data (>13%). Most of them (>82%) occurs when the healthcare workers input the measured data into the software app. Errors in the outliers are easy to detect but difficult for the inliers. A wrong data leads to a wrong decision. Personalized triage will be installed into the software app to detect errors at the earlier stage.

Collaborating with Grameen Communications in Bangladesh, we designed a Portable Health Clinic System [Fig.1,2,3] aiming to (1) improve people's access to quality and affordable healthcare services, (2) reduce medical errors, to improve patient safety, and to optimize remote healthcare processes. An ad-hoc triage system was introduced to instantly determine the health status of the patients in four different colors [Fig.4]. Only orange and red marked patients (38%) were given online consultancy with the doctors. The doctors' time is the most precious. In this process, 62% of doctors' time was saved. However, we have found that around 13% of the records were either faulty or incomplete. Unusual data at outliers are very easy to detect but not the errors in inliers.

Fig.1. Portable Health Clinic (PHC) Box

Fig.2. Health care worker

Fig.3. Health checkup by health care workers

Year	Records	Results			
		Safe	Cautious	Affected	Risky
2010	**377**	103	15	248	10
2012	**6,412**	1,056	4,035	1,084	237
2013	**13,277**	1,595	6,781	4,301	546
2014	**5,288**	1,004	2,278	1,659	326
2015	**5,547**	1,330	1,429	2,016	772
2016	**7,008**	1,875	1,614	2,255	1,070
2017	**1,640**	247	381	528	214
Total	**39,549**	**7,210**	**16,533**	**12,091**	**3,175**

Fig.4. PHC patients and their health status taken in Bangladesh

２．研究の目的

This study aims to reduce erroneous healthcare data of **remote healthcare systems**. The **key scientific questions** are the following:

1. What is the **nature of errors** in remote healthcare systems? Where, how and by whom do they occur?

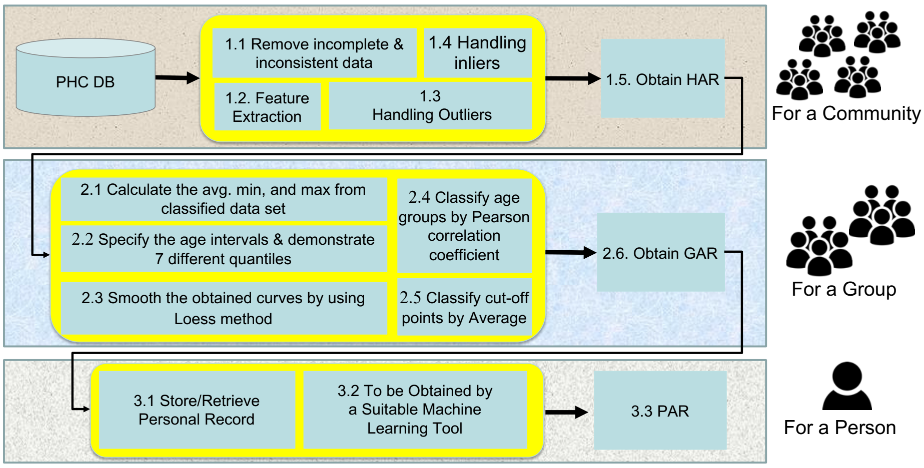
2. How to detect suspicious data, clean outliers, **predict missing data** in remote healthcare systems?

3. How can we mathematically define Personalized Triage?

4. How to evaluate the effectiveness of personalized triage for human assisted remote healthcare systems?

３．研究の方法

Most of the errors occur due to the human input errors by the healthcare workers at the remote site. Data errors lead to a wrong clinical decision made by a physician. Even if an error is identified by a physician it is not cost effective to remeasure the data and fix the errors. We came up with a software solution to predict three different acceptance ranges- (a) for a particular community (b) for an age group and gender and (c) for a particular person, we call them Human Acceptance Range (HAR), Group Acceptance Range (GAR) and Personal Acceptance Range (PAR).



４．研究成果

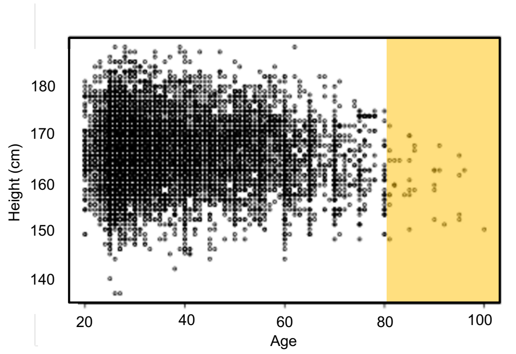
Remote healthcare data carries more errors than usual clinical data. Most of the errors occur due to the human input errors by the healthcare workers at the remote site. Data errors lead to a wrong clinical decision made by a physician. Even if an error is identified by a physician, it is not cost effective to remeasure the data and fix the errors. We came up with a software solution to predict three different acceptance ranges- (a) for a particular community (b) for an age group and gender and (c) for a particular person, we call them Human Acceptance Range (HAR), Group Acceptance Range (GAR) and Personal Acceptance Range (PAR).

To examine our concept, we carried out statistical analysis to detect outliers. Outliers are easy to detect but not inliers. Errors exist in inliers too. We have found 18% incomplete data, where 5.86% were unusual. The challenge is to detect whether these are errors or simply unusual.

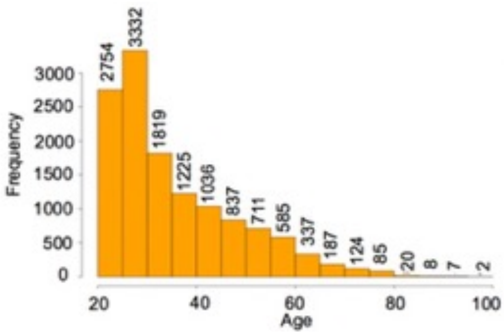
The three significant research contributions are listed below:

1. Growth pattern analysis: We analyzed 40,391 data and demonstrated the growth patterns for the anthropometric items (e.g., Height, Weight, BMI, Waist, and Hip) for both males and females. The patterns can be used to feedback the remote healthcare systems to predict and detect errors during healthcare data collection. As our aim is to identify if there is any similar groups, we analyzed anthropometric items by each age and five intervals of age groups. From the eye-ball estimation, we found three groups for each anthropometric items that can be classified with similar growth patterns. For male height, there is no sharp change until the age of 49, but after the age of 50, we observe a slight decline and a sharp decline after the age of 80. Male weight grows until the age of 49 and decline after that. Male waist and hip show similar growth characteristics with weight. For the female height there is no sharp change until the age of 44, but after 45, we can observe a slight decline. The growth pattern is quite similar to male height. Female weight

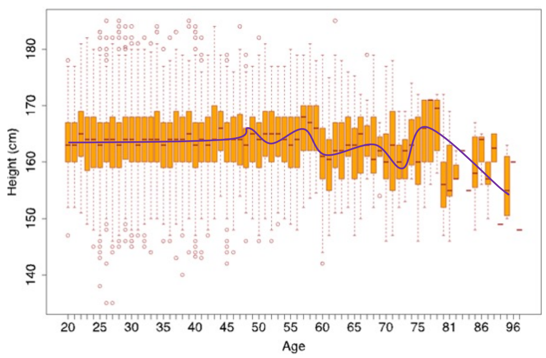
grows until the age of 46 and another decremented pattern we can observe after 47. We can obtain incremental pattern up to 47 years of age in BMI and another slightly decremented pattern we observe up to 65 years of age. For waist and hip there are incremented pattern until the age 48 and mixed pattern, we observe up to 65 years of age.



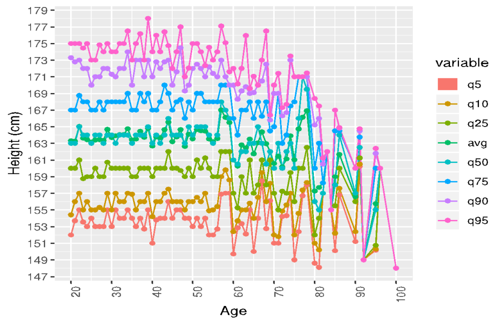
Distribution of Male Height (N=13,069)



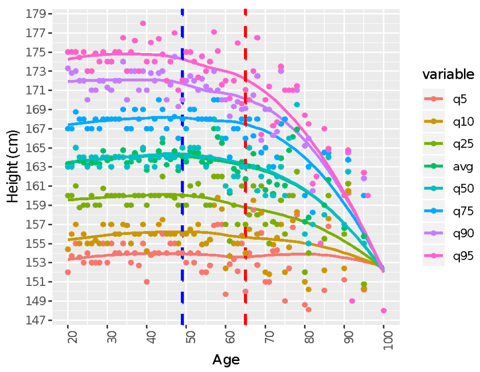
Frequency Distribution of Male Height (N=13,069) by Histogram



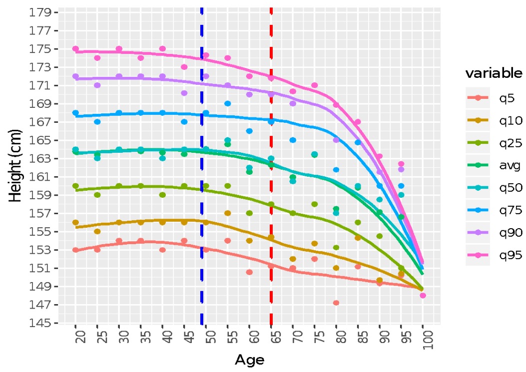
Age vs Height of Pattern of Male (N=13,069) by Box Plot



Age vs Height Pattern of Male in 7 quantiles



Age vs Height Pattern of Male in 7 quantiles. Smoothened by LOESS Function



Age vs Height Pattern of Male in 7 quantiles. Smoothened by LOESS Function, aggregated 5 years of intervals

2. Group Acceptance Range (GAR): Second, we proposed the Group Acceptance Range (GAR) based clinical growth patterns for both genders. In order to formulate the GAR, we identified the cut-off point based on age from the growth pattern for each anthropometric items. And from that cut-off point, we have calculated different acceptance ranges. For male height the

cut-off points of are 41 years of age and 57 years of age, the cut-off points for weight is 40 years of age and 57 years of age, the cut-off points for BMI is 42 years of age and 59 years of age, the cut-off points for waist is 41 years of age and 57 years of age. The cut-off points for hip are 41 years of age and 56 years of age. In a similar process, we identified the cut-off points for female height is 40 years of age and 55 years of age. The cut-off points for weight is 41 years of age and 57 years of age, the cut-off points for BMI is 46 years of age and 68 years of age, the cut-off points for waist is 40 years of age and 56 years of age, the cut-off points for hip is 40 years of age and 56 years of age. These cut-off points help us to understand the similarity and dissimilarity among different age from 20- 100, which leads to formulating the age groups. And finally, we have identified the acceptance ranges for different groups. The GAR can be estimated by analyzing past healthcare data. This range will be applicable for the patients who come for the second time for healthcare checkup. In the existing data (N = 40, 391), we have found 18% incomplete, unusual, and uninterested data, where 5.86% are unusual. In order to evaluate the GAR, we prepared an experimental field in Bangladesh. By organizing PHC service campaign (four times) we gathered 999 healthcare data from similar patients. In the first phase, we have found 1.62% unusual and 0.00% error data. In the second phase, it reduces and we have found 1.00% unusual and 0.00% error data. In the thirds phase, the ratio was the same and, we have found 1.00% unusual and 0.00% error data. However, in the fourth phase, we have found 1.63% unusual and 0.00% error data. A major observation is the error rate was 0.00% in every cases and unusual data was reduced to 4.23%.

3. Personalized Acceptance Range (PAR): Third, we proposed the Personalized Acceptance Range (PAR) based on HAR and GAR for a particular person. PAR can be estimated from biological growth pattern of that person. The range will be applicable for a person who has enough medical records to determine a trend.

In most of the cases, medical devices/sensors, especially for non-communicable diseases, are just used to collect the healthcare data to the server end. If we can integrate the efficient algorithm and integrated the intelligence inside the devices/sensors, it would be helpful to design personalized device/sensors. However, in order to design efficiently, there are a couple of challenges. Detecting and reducing errors is one of the major arenas. The findings of this research are expected to improve the efficiency of remote healthcare systems by detecting and reducing input errors. This improved approach will help not only to increase the efficiency of remote healthcare systems but also to reduce cost and time for the services.

5．主な発表論文等

〔雑誌論文〕　計5件（うち査読付論文　5件／うち国際共著　5件／うちオープンアクセス　5件）

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掲載論文のDOI（デジタルオブジェクト識別子） 10.1089/tmj.2018.0081	査読の有無 有
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1．著者名 Hasan Mehdi, Islam Rafiqul, Yokota Fumuhiko, Nishikitani Mariko, Fukuda Akira, and Ahmed Ashir	4．巻 10
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2．論文標題 Growth Characteristics of Age and Gender-based Anthropometric Data from Human Assisted Remote Healthcare System	5．発行年 2019年
3．雑誌名 International Journal of Advanced Computer Science and Applications	6．最初と最後の頁 615-619
掲載論文のDOI（デジタルオブジェクト識別子） 10.14569/IJACSA.2019.0100379	査読の有無 有
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１．発表者名
ampa Begum Masuda, Md. Nazmul Hossain, Rakibul Hoque, Rafiqul Islam, Fumihiko Yokota, Mariko Nishikitani, Akira Fukuda, Ashir Ahmed

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２．出版社 IET	５．総ページ数 400
３．書名 Mobile Technologies for Delivering Healthcare in Remote, Rural or Developing Regions	

〔産業財産権〕

〔その他〕

Social Tech Lab
www.socialtech.gramweb.net
Portable Health Clinic
http://ghealth.gramweb.net/

６．研究組織

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７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計1件

国際研究集会	開催年
International Conference on Healthcare, SDGs and Social Business	2019年～2019年

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関