Analysis on Nursing Care Activity Related Stress Level for Reduction of Caregiving Workload

Atsushi Miyaji, Tomokazu Matsui, Zhihua Zhang, Hyuckjin Choi, Manato Fujimoto, Keiichi Yausmoto

Nara Institute of Science and Technology, Graduate School of Science and Technology Ubiquitous Computing Systems Laboratory
Introduction

Background

- In Japan, **rapidly aging population** is a problem

  The demand for nursing homes is increasing

- **The shortage of caregivers** is becoming more serious

  Approx. two-thirds of facilities reported feeling a shortage

  Fear of increased workload for caregivers

---

[1] 内閣府, 令和2年度高齢者白書
[2] 公益財団法人介護労働安定センター, 介護分野の現状等について

[2019年] 65歳以上の人口 [%]

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>20%</td>
</tr>
<tr>
<td>2005</td>
<td>25%</td>
</tr>
<tr>
<td>2015</td>
<td>28.4%</td>
</tr>
</tbody>
</table>

A serious problem of nursing homes
Introduction

Efforts to Reduce the Workload of Caregivers \([3]\)

- Development of a platform for easy collection of caregiving behaviors

RSSI signal from BLE beacon

Estimating where the elderly stay

Care record automatically generate

Dramatically reduce the work of creating nursing care records

Isn’t the stress of caregivers having a significant impact on operational efficiency?

Focusing on the stress of caregivers, we aim to acquire new knowledge for reducing workload.

- An objective review of caregivers’ own work styles
- Review of work plans
- Encourage leave for refreshment etc...
Related Work

Stress Assessment Using Questionnaires

- **The Brief Job Stress Questionnaire** [4]
  - To prevent workers’ own mental health problem
    - Work-related stress factors
    - Stress response
    - Factors influencing stress (e.g., family, colleagues)

- **WHOQOL-100** [5]
  - To evaluate QoL (Quality of life)
    - Physical
    - Psychological
    - Independence
    - Social relationships
    - Environment
    - Spirituality/Religious/Beliefs

---


Stress Assessment Using Questionnaires

- **The Brief Job Stress Questionnaire** [4]
  - To prevent workers’ own mental health problem
    - Work-related stress factors
    - Stress response
    - Factors influencing stress (e.g., family, colleagues)

- **WHOQOL-100** [5]
  - To evaluate QoL (Quality of life)
    - Physical
    - Psychological
    - Independence
    - Social relationships
    - Environment
    - Spirituality/Religious/Beliefs

---


2 Related Work

Stress Assessment Using Questionnaires

- **The Brief Job Stress Questionnaire** [4]
  - To prevent workers’ own mental health problem
    - Work-related stress factors
  - WHOQOL-100 [5]
    - To evaluate QoL (Quality of life)
      - Physical
      - Psychological
      - Independence
      - Social relationships
      - Environment
      - Spirituality/Religious/Beliefs

The number of question is very large and the burden on the respondents is heavy

2 Related Work

Stress Estimation Method Using Devices

- **Research by Fukuda et al. [6]**
  - Estimation of mental and physical state of office workers from sleep data acquired from wearable devices

- **Research by Gjoreski et al. [7]**
  - Estimating stress of students using data collected from smartphones (acceleration, GPS, Wi-Fi, etc.) in three levels

Not yet able to estimate stress by activity

---


2 Related Work

Stress Estimation Method Using Devices

- **Research by Fukuda et al.** [6]
  - Estimation of mental and physical state of office workers from sleep data acquired from wearable devices

- **Research by Gjoreski et al.** [7]
  - Estimating stress of students using data collected from smartphones (acceleration, GPS, Wi-Fi, etc.) in three levels

Not yet able to estimate stress by activity

Visualize and analyze the relationship between caregiving behavior and stress state using devices

---


Method for Measuring Psychological Indicators

Objective Stress Indicators (HRV)

- The heart rate variability (HRV)

Calculated from periodically fluctuating heartbeat intervals
Method for Measuring Psychological Indicators

Objective Stress Indicators (HRV - RRI)

● The heart rate variability (HRV)
  Calculated from periodically fluctuating heartbeat intervals

☐ RRI
  Calculated from the interval between the R wave, a characteristic wave of heart rate variability, and the next R wave
Lorenz Plot

A method for estimating stress from RRI, expressing fluctuations in heart rate

RRI

Lorenz Plot
Method for Measuring Psychological Indicators

Objective Stress Indicators (HRV - RRI)

- Lorenz Plot

A method for estimating stress from RRI, expressing fluctuations in heart rate

\[ S = \pi \times \sigma_x \times \sigma_{-x} \]

Small area: Stress
Large area: Relax
Method for Measuring Psychological Indicators

Objective Stress Indicators (HRV - LF/HF Ratio)

- LF/HF Ratio

Calculated by converting RRI time series data into power spectrum
3 Method for Measuring Psychological Indicators

Objective Stress Indicators (HRV - LF/HF Ratio)

- LF/HF Ratio
  
  Calculated by converting RRI time series data into power spectrum

\[
\begin{align*}
0.04 \sim 0.15 \text{Hz} & \quad \text{LF} \\
0.15 \sim 0.4 \text{Hz} & \quad \text{HF}
\end{align*}
\]

- LF/HF Ratio is **High**
  - Stress
- LF/HF Ratio is **Low**
  - Relax
3 Method for Measuring Psychological Indicators

Subjective Stress Indicators

- Questionnaire Index
  - Work Engagement
    A measure of how enthusiastic a person is about work
  - DAMS (Depression and Anxiety Mood Scale)
    An index to measure positive, depressive, and anxious moods

Caregivers are asked them to answer questionnaires for three times
(Before work, During lunch breaks, and After work)
Experiment 4

About

During

2020

11/20 → 11/30

Place

Ikoma City, Nara, Japan

Total 10 days

Ikoi-no-ie 26

Target

Five Caregivers
### Experiment

#### About

<table>
<thead>
<tr>
<th>Answer the preliminary questionnaire</th>
<th>Wear the heart-rate sensor</th>
<th>Answer the daily questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the start of the experiment</td>
<td>Before work※</td>
<td>Before work, Lunch break, and After work</td>
</tr>
<tr>
<td>Status of caregivers (Gender, Experience)</td>
<td>Heart-rate sensor WHS-3</td>
<td>Based on DAMS &amp; Work Engagement</td>
</tr>
</tbody>
</table>

※Wearing is not compulsory
Nursing Care Activity

- Toilet Assistance
- Bed Assistance
- Rehabilitation Instruction
- Recreation Instruction
- Work in the Living Room
The Answer of Preliminary Questionnaire

- **Gender**
  - Man - 1 person
  - Woman - 4 persons

- **Experience**
  - More than 3 years, Less than 5 years - 1 person
  - More than 5 years, Less than 10 years - 1 person
  - More than 10 years - 3 persons

Most people have many years of experience
The Answer of Daily Questionnaire

- Vigorous
- Happy
- Enjoy
- Gloomy
- Disagreeable
- Dull
- Worried
- Anxious
- Afraid

Levels of each item:
- Before
- Lunch
- After
The Answer of Daily Questionnaire

Depressive
Anxious

Increased after work
Decline in mood

Level of each item

Vigorous, Happy, Enjoy, Gloomy, Disagreeable, Dull, Worried, Anxious, Afraid

Before, Lunch, After

Positive
Depressive
Anxious
5 Work Engagement

Result

The bar chart shows the level of engagement in different items of a questionnaire before, during lunch, and after. The items include Energy, Enthusiasm, and Focus and immersion. The chart indicates a noticeable improvement in all items after the intervention.
5

Result

Work Engagement

![Bar chart showing levels of Energy, Enthusiasm, and Focus and Immersion before, during lunch, and after work with comments on lowest vitality after work.](image)

- **Vitality**
- **Enthusiasm**

Items of questionnaire

- Energy
- Enthusiasm
- Focus and immersion

Levels:
- 7
- 6
- 5
- 4
- 3
- 2
- 1
- 0

Before
Lunch
After
5 Overall Tendency

- We were not able to collect data on all subject
  - Wearing the heart rate sensor (WHS-3) was not compulsory
  - Wearing was insufficient

Data that could be collected in the end
2 caregivers, total of 6 days
5 LF/HF Ratio Boxplots

High LF/HF Ratio ➤ Stress

ID_01

ID_02
Result

**LF/HF Ratio Boxplots**

- **ID_01**: Bed Asst.
- **ID_02**: Rehab. Instruction, Bed Asst. and Toilet Asst.

**Higher values**

- **ID_01**: Bed Asst.
- **ID_02**: Rehab. Instruction, Bed Asst. and Toilet Asst.

**High Possibility** of being in stress state
Could the caregiver's behavior have prevented the collection of sufficient sensor data?

Outliers are **widely distributed**
Lorenz Plot Area

**Activity with High LF/HF Ratio**

ID_01

ID_02

*Small Area → Stress*
5 Lorenz Plot Area

**Result**

**Lorenz Plot Area**

- **Activity with High LF/HF Ratio**

<table>
<thead>
<tr>
<th>Area</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>1000</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>1500</td>
</tr>
<tr>
<td>Recreation</td>
<td>2000</td>
</tr>
<tr>
<td>Bed</td>
<td>2500</td>
</tr>
<tr>
<td>Toilet</td>
<td>3000</td>
</tr>
</tbody>
</table>

**ID_01**
- Small Area
  - Bed Asst.

**ID_02**
- Small Area
  - Rehab. Instruction and Toilet Asst.
- **High Possibility** of being in stress state
  - Similar Trend in LF/HF Ratio

---

International Workshop on Applications of Wireless Ad hoc and Sensor Networks (AWASN'21)

2021. 8. 9
Mental load was small for one-to-many activities.
6 Future Issues

- The amount of data was not sufficient
  - Nearly half of the subjects did not wear the sensor
  - The questionnaire was not answered

It is difficult to collect data while actually performing cursing care tasks

Some ingenuity is needed
(Use of devices that do not affect the work, Reviewing the questionnaire)
Future Issues

- Differences among facilities and services
  - We received the opinion that the mental state changes depending on the person (e.g., dementia patient) being treated

- Differences in personalities
  - By incorporating questionnaires such as the Big Five in our experiments, we may be able to observe differences in personality and stress changes

Currently, we are continuing the experiment in another nursing home
Conclusion

● Overall
  - Visualization and analysis of changes in caregiving activity and psychological state
  - From the objective stress index, we were able to confirm that the caregivers were under stress in certain caregiving activity

● Future Work
  - Review the devices and survey indicators used
  - Ongoing data collection
  - Building a stress estimation model based on the obtained data