Intelligent Support System for Health Monitoring of elderly people

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This thesis is submitted to the School of Computing at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Computer Science. The thesis is equivalent to 20 weeks of full time studies.

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ABSTRACT

The use of information and communications technology (ICT) to provide medical information, interaction between patients and health-service providers, institution-to-institution transmission of data, in known as eHealth. ICT have become an inseparable part of our life, it can integrate health care more seamlessly to our everyday life. ICT enables the delivery of accurate medical information anytime anywhere in an efficient manner.

Cardiovascular disease (CVD) is the single leading cause of death, especially in elderly people. The condition of heart is monitor by electrocardiogram (ECG). The Electrocardiogram (ECG) is widely used clinical tool to diagnose complex heart diseases. In clinical settings, resting ECG is used to monitor patients. Holter-based portable monitoring solutions capable of 24 to 48-hour ECG recording, they lack the capability of providing any real-time feedback in case of alarming situation. The recorded ECG data analyzed offline by doctor. To address this issue, authors propose a functionality of intelligence decision support system, in heart monitoring system. The proposed system has capability of generate an alarm in case of serious abnormality in heart, during monitoring of heart activity.
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**THESIS STRUCTURE**

Our research work highlights on the current heart monitoring system and its gaps. We will propose IDSS based heart monitoring system to fill such type of gaps. Our proposed system may help the doctors for heart patients at the time of any alarming conditions. It may also store the whole information such as diet, exercise, previous heart attacks, and family problems. At the time of any abnormality of the patients, it will also give an alert to the health care providers. After literature review, questionnaires and interviews from the concerned personals will conduct to get the most suitable information about the performance and issues in current heart monitoring system.

**Chapter #1; Introduction**

The background of our research area has been described briefly in this chapter. The authors have explored different concepts about e-health, health monitoring system and its functionality.

**Chapter # 2; Problem Definition & Goals**

The problems definition regarding functionality of heart monitoring system have described in this chapter. The authors have also presented here the research questions about their domain with aims and objectives for expected outcomes.

**Chapter # 3; Research Methodology (Case Study)**

This chapter is about research methodology for the whole thesis work and here the authors have explained about the approaches and methods for literature review, questionnaires and interview.

**Chapter # 4; Systematic Literature Review**

The main part of our research domain exists in this chapter. In this chapter, the authors have discussed about heart monitoring system, different devices for heart monitoring, Holter Monitor with its functionality and effectiveness. The shortcoming and drawbacks of the current Holter Monitor through literature review have been also discussed in this chapter.
Chapter # 5; Empirical Study/Case

The empirical study has been discussed in this chapter. The case for proposed system with decision support and intelligent decision support system are discussed. Procedure for questionnaire and interviews are designed before conducting the survey and interview from heart patients and healthcare personnel. The designed questions have been asked to have strong information regarding our domain.

Chapter # 6; Results

The result obtained from the interviews and the surveys have been described graphically in this chapter.

Chapter # 7; Discussion/Analysis and Validity Statements

This chapter consists of discussion/analysis and validity statements on the basis of the results, which have been gathered from the interviews and surveys.

Chapter # 8; Conclusion

The research conclusion and future work based on this research study is included in this chapter.

References

Appendix
1. INTRODUCTION

Implementation of computer technology in all fields of life, is very useful either it is about crossing through the door or measuring nutrition value in a cup of tea. In computer technology, innovation is increasing day by day and improving the capabilities to overcome the problems faced by the human beings. Although it is an old story to implement IT in health care field, but still in some fields of health care, computer applications can make a difference. To improve the quality of life for heart patients by computer application is one of the most important.

E-Health is valuable use of information and communications technology (ICT) to provide medical information, maintaining the patient’s record in electronically, and support user interaction with the system [10]. “E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies” [68]. E-Health also emphasizes on the use of ICT in the field of health and medical care including, electronic prescriptions, electronic health records, digital imaging and health information directed at citizens via web portals. E-Health services facilitate the easy and secure exchange of vital health data between healthcare providers, policy makers and patients [81].

Heart diseases are very dangerous, chronic and miserable for the life therefore some time a patient may have sudden death due to such kind of chronic diseases. Precautionary, a patient should have some diets, exercise, medicines and visiting to the doctors for consultation but it is not easy for the old patients to move frequently to their doctors for checkup and other precautionary measures. It is a difficult task for the doctors and care givers to handle such kind of patients because some time heart diseases become lethal. The medical staff also has to maintain the history of the patient’s i.e. previous heart problem, abnormality of heart beats, heart attacks, diet, medicine, exercise, heart patient in the family and visit to the doctors. This information supports for optimal decision of the medical staff to safe the patient from sudden mishap. To overcome these problems in health care especially in heart department, Intelligent Decision Support System (IDSS) is a very helpful solution [62].

Intelligent Decision Support System (IDSS) based heart monitoring system will very helpful for the both health care providers as well as for the heart patients [62]. Due to such intelligent decision support system, heart attacks, rate of sudden death, unnecessary visits of the patients to the doctors and unnecessary expenses may also be reduced.
IDSS based system will be helpful to make quick optimal decision for providing understandable information of the patients to the doctors for necessary decision. The patients also demand such type of system which helps them to make remotely communications with health care providers due to any heart problems and reduce their continuously and unnecessary visits to the hospitals. So the system should be accessible remotely. There are many sophisticated devices for recording i.e. Medtronic Reveal® Insertable Loop Recorder [71]. These record the data of ECG for up to the time period of fourteen months. With the help this device, by doing an experiment for fainting episode, user can press the activation button with his hand. The physicians can analyze from the stored information of a specific time period to determine whether it was remove by an abnormal heart rhythm. For example, if a patient suffers due to the serious rhythm irregularity, they perform only recording instead of real-time classification of ECGs and then the classification is performed off-line [47].

Figure 1: - Basic concept of e-Health (Swedish National e-Health strategy-2010)
E-Health concept is about how we can combine all societal actors in order to improve the information management within the healthcare system for the benefit of the patient, health professionals and decision-makers inside the healthcare sector.

1.1. National e-Health Strategy (Sweden)

The health and social care sector is one of the most sensitive and information-intensive sectors in Swedish society. Therefore, the need for efficient information supply between different actors is absolutely crucial. With the help of Information and communications technology, Clinical information can be presented and transferred more securely and more efficiently throughout the entire health and social care sector. The Swedish government, emphasis on deployment, use and benefit of the technology rather than its development, and changes the name of the “National Strategy for e-Health to National e-Health - the strategy for accessible and secure information in health and social care” [72].

In 2006, Swedish central government adopted the National Strategy for e-Health. In this policy the entire implementation process is divided into following six action areas, which are defined as:

- “Bring laws and regulations into line with extended use of ICT,
- Create a common information structure,
- Create a common technical infrastructure,
- Facilitate interoperable, supportive ICT systems,
- Facilitate access to information across organizational boundaries,
- Make information and services easily accessible to citizens[73]”

The prior three areas are concerned with establishing better primary conditions for ICT in health and elderly care. The remaining three subsequent are related with the improvement of e-Health to patient perspective. In 2010 the “National Strategy for e-Health has been revised to the National e-Health Strategy for accessible and secure information in health and social care and communication technologies (ICT)”. The objectives of this new version of National e-Health strategy are improvement in following three main areas [72].

- The patient and his/her relative or friends shall have easy access to all information regarding patient.
- Doctors and health care related staff shall have guaranteed and easy access of day to day necessary and structured information about the patients.
The management of health and social care shall have facility to continuously monitor and obtain up-to-date information, which helps them in decision making process.

1.2. Health Monitoring System

Health monitoring system is used to monitor the patient activity and get the clinical information. Remote monitoring of patients at home, with the help of telecommunication and information technologies is an emerging field in healthcare. Monitoring system may include video-monitoring, telemonitoring, messaging reminder, alerts. With the help of monitoring systems, the health professional, monitor the electrocardiogram, pulse oximetry, glucose, and movement or position detectors. These technologies provide the clinical information about the patient’s current condition and support the medical professional for decision making [5].

Fast development in communication and information technology have opened a numerous of new trends of healthcare delivery in far-flung areas. This new form of service delivery, not only provides the healthcare facility to far-away populations, but also makes it possible to monitor the health condition of elderly and chronically ill patients at their homes. Due to the alarming increase in the population suffering from chronic diseases in advance countries [57], that has absolutely distorted the healthcare systems in these countries. Chronic diseases should be monitored properly during all phases of the treatment [44].

Health monitoring systems can play an important role in improving the lives of patients, especially the weaker part of the population including disabled, elderly and chronically ill patients [39]. Such patients may be able to get standard healthcare facility without visiting to their doctor regularly. These technologies facilitate to both patient and doctors. Doctors can save their time and focus more on priority tasks and the patient avoid making extensive visits to the doctor, especially if they live in a remote location. Moreover hospitalizations expenses decreasing due to use of the technology [17]. In case of chronic diseases such as diabetes and heart problem in remote areas, there is acute a shortage of specialists, which is a big challenge facing by most countries in the world [59]. The health monitoring system solves this problem and improves the overall quality of health service in remote areas. There are major two types of monitoring systems, telemonitoring and video monitoring.

1.3. Telemonitoring

Telemonitoring is an emerging trend in medical field in which telecommunications and information technologies used for diagnosing and treatment of diseases of elderly people at home. It facilitates the patient to get specialized medical treatment 24 hours a day
independently at his/her location. Telemedicine has been accepted in advance countries. Most of telemonitoring studies however focus on chronic diseases like diabetes and heart patient population [12, 27, 42, and 55]. In the most of the cases, the process consists of acquiring vital clinical data (e.g. blood pressure or Sugar level) and other biomedical signals (e.g. ECG signals) periodically and to record them locally. Later on sending them to a remote telemedicine center, where a specialist or healthcare professional analyzed this data [34].

A video monitoring system is used to detect falls and other critical situations of patients living single at home. Elderly are particularly at high-risk situations. For example, if an elderly person falls at home and cannot call for help independently, it often takes hours or even days to get emergency assistance. The video monitoring system is to mitigate such kind of situations. If an emergency is detected, an automatic alarm will be raised [6].

The consequences of a fall are more severe in case of the elderly as compare to younger people [36]. The situation is alarming especially with elderly living single at home [51]. In such situation, they cannot call for help after a fall. In such circumstances, it often takes hours or even days until relatives, neighbors, or medical personnel detect the emergency [20].

1.4. Health Monitoring System for Elderly

In the most developed and developing countries, the population of elderly is increasing faster than any other segment of the population. According to ‘WHO’ report the population of elderly people having age 60 or above will be double in the year 2025 [82]. Sweden is a country having the oldest population in the world after Italy, Greece, and Japan and nearly 24% of population in Sweden (about 2.2 million) were in group in population having age 60 or above in 2006. It is estimated that in 2035 the greater part of the Swedish population will be in aging group, which are unable to work [83]. Elderly are the largest consumer of health care in Europe [10]. They consume three times healthcare resources as compare to other age groups [21]. There are increasing numbers of elderly people in Europe as well as in the other developed countries [30]. From the last three decades, there has been an increased reliance on the family to provide help to their sick old relatives but now in the developed countries especially in North Western Europe, it is carried out by the state [32]. Sweden spends a major portion of its gross domestic products (GDP) for its elderly citizens than any other country in the world [9, 48].
According to the World Health Organization reports, chronic diseases, such as heart disease, stroke, cancer, chronic respiratory diseases, and diabetes, are by far the leading cause of mortality in the world, representing 60% of all deaths [32, 76]. The proportion of people aged over 60 years is growing faster than any other age group, because of both longer life expectancy and declining fertility rates. Coronary heart disease is the leading killer of older people; half of all heart attack victims are over 65. The large amount of patients with chronic diseases and the increasing percentage of older adults, combined with the rising cost of medical procedures, will place an enormous strain on the world’s healthcare industry [33]. More than 160,000 Swedes are being affected by the heart failure, which is approximately 2% of the total population, in this percentage 10 to 15% people are more than 75 year of age [67].

According to official statistics of Sweden regarding health and medical care, almost 72% of all deaths were in the age group of 75 years or over. The leading cause of death for both men and women was Heart diseases (circulatory system), which was the primary cause of death among 39% of men and 41% of women by the year 2010 [79]. Cardiovascular diseases kill more people each year than any other disease. According to (W.H.O) report, the underlying cause of death in the world by the year 2008 was cardiovascular diseases, as shown in the following table.

<table>
<thead>
<tr>
<th>Disease Name</th>
<th>Deaths in millions</th>
<th>% of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischaemic heart disease</td>
<td>7.25</td>
<td>12.8%</td>
</tr>
<tr>
<td>Stroke and other cerebrovascular disease</td>
<td>6.15</td>
<td>10.8%</td>
</tr>
<tr>
<td>Lower respiratory infections</td>
<td>3.46</td>
<td>6.1%</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>3.28</td>
<td>5.8%</td>
</tr>
<tr>
<td>Diarrhoeal diseases</td>
<td>2.46</td>
<td>4.3%</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>1.78</td>
<td>3.1%</td>
</tr>
<tr>
<td>Trachea, bronchus, lung cancers</td>
<td>1.39</td>
<td>2.4%</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>1.34</td>
<td>2.4%</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.26</td>
<td>2.2%</td>
</tr>
<tr>
<td>Road traffic accidents</td>
<td>1.21</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Table 1: - Cause of death in the world by the year 2008
Cardiovascular diseases are defined as the “disorder of the heart and blood vessels”. Cardiovascular disease (CVD) includes:

- Coronary heart disease (CHD): disease of the blood vessels supplying the heart muscle;
- Cerebrovascular disease (Stroke): disease of the blood vessels supplying the brain
- Peripheral arterial disease: disease of blood vessels supplying the arms and legs
- Rheumatic heart disease: damage to the heart muscle and heart valves
- Hypertension: raised blood pressure
- Heart Failure: heart is not pumping as well as it should.
- Congenital heart disease: malformations of heart structure existing at birth [77]

The normal heart is like a strong and hard-working pump. Heart is made of muscle tissue having size little larger than a person's fist. The normal human heart is composed of four chambers, two upper chamber called atria and the lower two chambers called ventricles. There is a wall of tissue called septum between these chambers are strong, hard-working pump made of muscle tissue. The heart also contain four valves helping pumping the blood through these chambers. The blood flows by opening and closing of these valves. Each valve has a set of flaps. The blood flows only in one direction [65]. The electrical system of the heart is also called the cardiac conduction system. The Electrical signals of heart called heartbeat (expands and contracts) control the pumping system of the heart. The heart's electrical system has three main parts:
  - The sinoatrial (SA) node.
  - The atrioventricular (AV) node.
  - The His-Purkinje system.

The heartbeats generated when an electrical impulse initiated from the sinoatrial node (SA node) run through it. As the SA node initiates impulses for the heartbeat, so is also referred as the heart's "natural pacemaker". [74] The normal electrical cycle start from the right atrium and then passing through the both atria forward to the atrioventricular (AV) node. From the AV node, the electrical impulses go down to a group of specialized fibers called the His-Purkinje system to all parts of the ventricles. In order to pump the heart rightly the exact rout must be followed. As long as the electrical impulse is transmitted normally, the heart pumps and beats at a normal pace. In an adult, a normal heart beats 60 to 100 times per minute [24, 26].

The condition of heart is monitor by electrocardiogram (ECG). The electrocardiogram (ECG) predicts the electrical activity of the heart and is valuable tool used to diagnose the heart related problems [3]. An ECG is a graphical representation of the electrical activity of the heart [31]. When upper chamber of heart are excited, they produce an electrical impulse
for duration approximately 300 ms [43]. The ECG is simple, effective and inexpensive test for the diagnosis of cardiovascular diseases. [41]. There are main two types of ECG namely resting ECG and ambulatory ECG. Resting ECG perform in hospital lab while ambulatory ECG taken while someone doing his normal activities.

Traditional heart monitoring system exist for many years such as the Holter device which records the patient’s ECG for 24 to 48 hours and is then analyzed by the cardiologist. The patient can ‘wear’ the Holter device, go home and perform his/her normal activities. The main drawback of these systems is unable to transmit any kind of information to concerned healthcare personnel, when a major incident occurs during the monitoring.
2. **PROBLEM DEFINITION & GOALS**

2.1. **Problem Definition**

There are many patients, who are in chronic condition and need long-term and ongoing health care [81]. Elderly people also prefer to stay in their own homes where they can have the right to use of public support, shopping, transportation services, social activities, and health care when they needed [75]. They need to have medical treatment at their doors, from the doctors in case of any emergency or abnormality in the working of heart. Therefore, many elderly people wish to remain as independent as possible in their own home for as long as possible [30].

It is not possible for the elderly heart patients to visit their doctor every day for regular checkup or any laboratory test. They are too weak to attend the hospital appointment regularly. On the other hand, patients have behavior to avoid from the visiting to the care provider [38]. Sometimes there is much crowd in clinics and hospital and patient have to wait for long time of their turn, which is also problem for patients [28, 8].

Heart monitoring system (Holter Monitor) is used for heart patients to get heart electrical activity data for analyzing their previous condition. The heart monitoring system is attached with the patients and after few days, the patients have to go to the hospital and cardiology department, the holter monitor attached with the system to get heart electrical activity data of the patients for analyzing. Although some time heart diseases, e.g. heart attacks become very dangerous and fatal and these should be controlled immediately but through the current Holter Monitor, it takes a time to know about any abnormality in heart. Sometimes even patients can not inform to the doctors during such serious attack.

Therefore, the above mentioned challenges and problems have contributed the significant role in our research study and encourage us to do research for IDSS (Intelligent Decision Support System) based heart monitoring system to save the life of elderly heart patients from any emergency. Therefore medical resources such as budget, life and time as well can be saved and can be utilized for constructive activities. Patients may have a lot of time to spend with their relatives and friend instead of in hospital because human beings are social animal and they want to interact with each other.
2.2. Aim & Objectives

The tools based on ICT (Information Communication Technology) are being used widely in healthcare domain for communication, exchange, storage and other activities regarding patient health. However, in case of emergency, the problem becomes more critical and dangerous when there have to access the patient’s information in time for providing health care.

We assume that the elderly citizens, who are heart patients and the doctors as well, will get great benefits by using the proposed IDSS based solution in future. The main goal of the study is to propose that how to monitor the chronic heart disease for elderly heart patients through intelligent support system. To achieve this goal, there are some following steps.

- To find out the difficulties facing by elderly people in using current heart monitoring system.
- Through literature study, questionnaire and interviews, we will find out the shortcoming in current heart monitoring system and why there is a need of intelligent heart monitoring system for elderly heart patients.
- To know, what has been done until now for elderly heart patient people in e-health domain?
- To evaluate and validate the effectiveness and consequences of the proposed intelligent heart monitoring system through case study.

2.3. Research Questions

Following research questions are going to be answered in our research work.

RQ1: - What are the functionalities of the current heart monitoring System for elderly citizens?

According to our first question, we will review the literature related to our research domain. We will look into the current heart monitoring system that is being used for heart patients. We will also try to find out the functionalities and effectiveness of the current heart monitoring system.

RQ2: - What are the shortcomings in current heart monitoring system?

This question will help us to highlight the issues and problems in current heart monitoring system. Literature review, questionnaire and conducting the
interviews will also help us to look into the challenges faced by the elderly heart patients and the medical staff as well.

RQ3: What function should be designed for the proposed intelligent decision support system?

Third question will help to find out the solution for the problems which have been explained through question # 2. It will also help that how the elderly heart patients as well as medical staff could be facilitated and how much beneficiaries they be, while using Intelligent Decision Support System in Holter Monitor.

RQ4: How can proposed Intelligent Support System for heart monitoring be validated?

Our fourth research question will give us the support, for the implementation and effectiveness of our proposed system, which is carried out through questionnaire from heart patients and interviews from concerned medical personnel.

2.4. Expected Outcomes

Our expected contributions from studying the question are as below:-

- Understanding of the current heart monitoring systems used for heart patients to get their heart electrical activity data.
- Understanding of why heart monitoring system is essential for heart patients.
- Analysis of patient’s difficulties related to heart monitoring system.
- Identification of issues in heart monitoring system.
- Proposed IDSS for heart monitoring system
- Discussion and results
3. **RESEARCH METHODOLOGY - (CASE STUDY)**

For our master thesis, we have selected qualitative research approach involving case study [1], [11]. The solution for our research questions will be obtained by approaching the subject through systematic literature review, surveys and interview. The detail of our research methodology can be described in a figure as below.

![Diagram of research methodology]

**CASE STUDY**

- **RQ1** Systemetic Literature Review
  1. Literature review about different concepts and definitions for elderly, e-health, heart monitoring system and its applications.
  2. Different types of heart monitoring system and its effectiveness.
  3. Current Holter Monitoring System
  4. Different factors that influence the adoption of IDSS based Holter Monitor.

- **RQ2** Shortcoming

- **RQ3** Intelligent Decision Support System for Heart Monitoring System (Proposed Holter Monitor)
  - Survey-II from heart patients
  - Interviews with Health Professionals

- **RQ4** Analysis & Validation

**Figure 2:** - Detail of research methodology
3.1. Case Study

Case study can be defined as a story about something unique and special. This can be about organization, institution, events, processes, programs or individual [52]. Case study is used to investigate the current events, which are existed in the context of real life [52]. It helps to look the story behind the results and a very good opportunity to highlight the success, challenges or difficulties of a project.

3.2. Advantages of a Case Study

The main advantage of a case study is that, it provide the more detailed information than any other method and also allow to the investigator to collect the data through multiple method such as literature review, observation, surveys and interviews [49].

3.3. Process for Conducting a Case Study

There are some general steps, which help for conducting a case study, such as plan, enveloping instruments, data collection, data analyzing, disseminate finding [49]. According to Neale, P, there are five major steps to perform case study [47].

- Designing a Case study
- Collection and preparation of data
- Collection of evidence
- Data Analysis
- Reporting

3.4. Types of Case Study

Case study has following three types [52].

- Descriptive

The main focus of this type of case study is to describe the theory or phenomenon and it is suitable when the investigators are good familiar about previous theories.
**Exploratory**

The main focus of this type of case study is to explore the theory or phenomenon and it is suitable when to explore about the gaps in the present knowledge.

**Explanatory**

The main focus of this type of case study is to develop a hypothesis or a theory based on theoretical or practical knowledge. It is suitable when the investigators interested to develop something about theory or hypothesis [8].

Although there has been much knowledge and research about our topic but still there are some gaps, which need to be filled with advance development. Therefore we have decided to perform exploratory case study to explore e-health regarding Holter Monitor for heart diseases. We tried to express the different aspects of the heart monitoring system. We have also tried to propose the best solution for heart patients and care givers in the form of IDSS based Holter Monitor.

### 3.5. Protocol of case Study

The protocols of a case study are the guideline for decision making to develop design, which will be helpful for data collection during research. In our thesis work the protocols of case study are comprised the following content, which has an important role to execute the case study.

- Research Question
- Method of data collections
- Systematic literature review
- Survey-I
- Survey-II
- Interviews
- Aim and objectives
- Documentations

### 3.6. Types of data collection

Systematic literature review helped us to analyse the contribution of health monitoring system for elderly heart patients. We concentrated on the finding information especially relevant to our research area. The study, of recent projects about health care system for
elderly heart patients, is used to improve the consequence of our research. According to P. Runeson [50] there are three types of methods to conduct case study.

- Direct Method (Interviews/Survey)
- Indirect Method (Observations)
- Independent (Documentation Analysis)

It has already mentioned that we are using exploratory case study including literature review, surveys and interviews [52], for our research work. The collection of data for our research work is based on all available documents, literature and other evidences (Articles, Journals, Conferences, and Books etc.). Therefore, we have followed independent technique for data collection. Systematic literature review is very helpful to obtain the documentation evidence [52]; so we have used to explore e-health organization for elderly heart patients for evolution of Holter Monitor.

Findings extracted from systematic literature review have been verified through survey-I to avoid researcher’s biasness. Survey-I was conducted from one concerned doctor and 4 heart patients (See chapter 5, section 5.7.4). The results of systematic literature review and survey-I was summarized for RQ2. Data collected through systematic literature review and survey-I helped to propose intelligent decision support system based heart monitoring system. The proposed system was validated through survey-II and interviews from the doctors.

3.7. Searching Strings

The major purpose of performing systematic literature review was to find out relevant research work that has been done on heart monitoring system. Preliminary search was carried out to extract relevant data with the following search strings.

- E-health
- Heart disease
- Heart monitoring system

After performing the preliminary search with the help of these search strings, authors using the Boolean operators to refine the search.

- Holter monitor and its functionality
- Intelligent decision support system
- Heart monitoring and issues
- Heart diseases and elderly

Total 406 papers have been found, described in section 3.9, table 3, Data extraction table. Furthermore, inclusion exclusion criteria will reduce the number of research papers.

### 3.8. Resources

First of all, we started to search for our finding with Google Scholar and Inspec/Compendex, but the set of results was vast and redundant. The results from Google Scholar and Inspec/Compendex also existed in ACM, Springer and IEEE. Due to the trustworthy and reliability of the sources, we have concentrated on IEEE and ACM.

### 3.9. Search Results

To extract the data, we have used different types of databases. The search results based on search string (see section 3.7) are described in search result table.

<table>
<thead>
<tr>
<th>Name of Sources</th>
<th>No of Articles</th>
<th>Selected Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE</td>
<td>70</td>
<td>19</td>
</tr>
<tr>
<td>ACM</td>
<td>58</td>
<td>12</td>
</tr>
<tr>
<td>Inspec</td>
<td>94</td>
<td>21</td>
</tr>
<tr>
<td>Google Scholar</td>
<td>46</td>
<td>15</td>
</tr>
<tr>
<td>Others</td>
<td>138</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>406</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 2: - Search results table
3.10. IDSS Based Proposed System

Systematic Literature review and survey-I helped us to find out the current heart monitoring system, its effectiveness, limitations and drawbacks. Therefore, on the basis of our objectives and to overcome the problems in the current heart monitoring system, we proposed an Intelligent Decision Support System base Holter Monitor to facilitate the elderly heart patients as well as the care providers. This system will help in the case of any abnormality and will send the alert to the medical staff to save the life of elderly heart patients. The validation of our proposed system has done through the interviews from medical staff.

3.11. Analysis and Validation

We have performed the case study based on available literature review survey and interview to achieve our goals. Through case study, we have discussed different aspects of e-health for elderly heart patients and heart monitoring system. We have proposed IDSS based heart monitoring system (Holter Monitor). For the verification and validation, we conducted structured interviews and survey-II including open and close ended questions.

Interviews were conducted from eight concerned medical specialist from Sweden, Denmark, Pakistan and China in order to get the most suitable information for better validation of our research work.
In this chapter, we present a systematic literature review to identify the functionalities and shortcoming in current heart monitoring system. Based on the results collected from systematic literature review, we conduct a survey to verify the shortcoming in current heart monitoring system. The result obtained from systematic literature review and survey. We proposed an intelligent decision support system for heart monitoring system to overcome the shortcoming in current heart monitoring system.

The systematic literature review (often called a systematic review) defined by Kitchenham “A systematic literature review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question” [92]. Individual studies contributing in any way to a systematic review are called primary studies, where as a systematic review is a type of secondary study. There are three main phases of systematic literature review mentioned below [92].

- SLR methodology is very well defined and helps to reduce the biasness for selecting primary studies.
- The systematic process used in SLR enables consistency in study selection and quality assessment of primary studies.
- The outcomes through SLR serve as input for further framework construction.

- Planning the Review
- Conducting the Review
- Reporting the Review

### 4.1. Planning the Review

Authors follow the guidelines defined by Kitchenham. In this phase planning of systematic literature review discussed. Following stages are associated with planning the review

#### 4.1.1. Identification the need of systematic literature review

The systematic literature review provides us an opportunity to summarize all the related research work, which has previously been done. We gathered the related research work
through an unbiased manner to find out empirical evidence that focus on functionalities and shortcoming of the current heart monitoring system for elderly heart patients. Our aim is to propose an intelligent decision support system for heart monitoring system. We assume that with the help of latest technology and research, we make the system more fruitful. Furthermore, any gap related to the current study is suggested for further investigation.

4.1.2. Development of review protocol

A review protocol is an important element that describes the methods for conducting systematic literature review. A pre-defined protocol play vital role to reduce the possibility of researcher biasness [92]. Review protocol provides us a way for selecting primary studies. The concerned search terms were applied before conducting the systematic literature review in order to obtain the previous related work done. In our thesis, the systematic review should be based on existing research work along with proposed research work, which will help to fills the gap in current body of knowledge [92]. The outcome of research work before systematic literature review shows that mostly the research has been carried out in recent ten years. Keeping in review this point, we select most of research papers/articles based on years from 2000 to 2010. However, some papers/articles have selected before 2000 to get historical data regarding our research work. In order to gather latest research knowledge, we select research articles without boundaries. The research work, which has been done in recent years, can help us to find out the gap related to heart monitoring system.

4.1.3. Search Strategy

The search strategy comprises of selection of research material and online resources based on search strings. Search strings and relevant resources are briefly described in chapter 3, section 3.7 and 3.8.

4.1.4. Criteria for Study Selection

In the following section, the relevant papers/articles are selected from primary studies. The criteria for study selection based on the following inclusion and exclusion criteria.

❖ Inclusion Criteria for Study Selection

The inclusion and exclusion criteria are defined to select the primary data from research papers and articles. Primarily selected articles will be reviewed further for most relevant studies and data extraction purpose. The inclusion criterion is defined to identify the primary studies related to heart monitoring system, its functionalities and shortcomings. Following is the criteria for inclusion and exclusion, which will be applied on selected studies.
The research papers or articles are selected that defines the heart monitoring system and other sort of relevant knowledge.

The research papers or articles are selected that may address the systematic literature review, case study, surveys and analysis reports.

The research papers or articles are selected that describe the functionalities, effectiveness and shortcoming of heart monitoring system.

The research papers/articles are selected which contains the data of some sort of cross reviewed.

The research papers or articles are selected that are freely available with full text.

 Exclusion Criteria for Study Selection

The articles and papers, which did not match with inclusion criteria defined as above were excluded from the selection of research papers/articles.

4.1.5. Procedure for Study Selection

The primary criterion helped us to identify the article weather it is concerned with our research work or not. Selection of primary study based on some key points about selected article in inclusion/exclusion criteria.

 Title of the research paper or article
 Abstract of the research paper or article
 Conclusions of the research paper or article

Inclusion of the article/paper based on above mentioned sections; full article reading considered in the primary reading if the article satisfy the inclusion criteria.

4.1.6. Study Quality Assessment Checklists

In order to set the quality checklist for primary study, we consider the different sections presented in research papers. These sections include introduction, background, research methodology, process of reports/results conducting and conclusion section. These checklists will be applied for the evaluation of research articles selected in primary study.

4.1.7. Strategy Used for Data Extraction

The data extraction strategy defines the method for extracting relevant data from selected research articles/papers [92]. Data extraction method depends upon the specific and general
information described in research articles, further explanations are given in the below section.

General Information

The general information regarding selected research articles was documented, are listed below:

- Title of the selected Article
- Name of Author(s)
- Name of Conference/Journal/ Date of Publish/Presented
- Relevant Search String(s) used to retrieve research article
- Database used to retrieve the research article
- Date of Publication

The specific information about selected research article was documented, described in appendix A.

4.1.8. Synthesis of Extracted Data

The data synthesis section defines to gather and summarize the results of primary research articles. The selected articles were distinct from each other based on research methodology and their results. Qualitative synthesis was suitable to document the results of the relevant research articles with respect to appropriate research questions [92].

4.2. Conducting the Review

Systematic literature review was conducted to obtain the maximum number of research articles/papers much relates to research questions using an unbiased strategy [92]. The review protocol explicitly defines the search strategy for performing systematic literature review. The following stages are associated with conducting the review

4.2.1. Identification of Research

Systematic literature review was conducted to obtain the maximum number of research articles/papers much relates to research questions using an unbiased strategy [92]. The review protocol explicitly defines the search strategy for performing systematic literature review. A general approach is to break down the research questions into small questions (individual facets) [92]. On the basis of these research questions search strings were defined by using AND/OR operators. The search strategy has been described in the review protocol
section 4.1.2. On the basis of search strategy a preliminary search is conducted to identify the relevant literature data from different resources.

4.2.2. Selection of primary studies
Two steps were performed in order to select the primary study. First of all the title, abstract and conclusion of the research articles were studied for the selection of relevant research work. In the second step inclusion and exclusion criteria described in section 4.1.4, was applied on the selected studies to gather relevant data.

4.2.3. Study quality assessment
Quality assessment of the selected primary research study is performed on the basis of their structure including Introduction section, research methodology, gathered results, conclusion etc details described in section (see section study quality assessment checklist, 4.1.6). The quality assessment procedure selects that primary research article which provides relevant information of research work.

4.2.4. Data extraction
In this phase, we gathered and documented all the extracted from the primary study, according to specific and general information described in research articles (see section Identification of research, 4.1.1). It is an easy way of extracting the relevant data from selected primary study. The outcomes of primary research articles were collected and summarized. In order to document the outcomes of the relevant research articles, qualitative synthesis was used for this purpose. To ensure the correctness of the extracted data, cross-checked was performed [92].

4.3. Reporting the review
Reporting the review is a single phase. In this single phase, the results of systematic literature review are presented with respect to research questions. In the following sections, the results of systematic literature review are presented.

4.4. Heart Monitoring
Initially the condition heart was monitored by placing an ear on the patients’ chest to listen the beats of heart. After that, about 200 years ago the stethoscope was invented by Rene Laennec, which made it possible to hear the heart beat more accurately [46]. However, it was still not possible to monitor and record the electric activity of the heart. At the start of the
20th century, the Dutch physiologist Willem Einthoven developed the first electrocardiograph (ECG) that made it possible to record the electric activity of heart on graphical paper [89]. Soon after the invention of the ECG, the Holter-monitor was developed by American biophysicist Norman J. Holter in the early 1960s [2]. The Holter-monitor is a portable device, which is capable to record the patient’s ECG during his/her daily activity for more than 24 hours.

4.5. ECG

The condition and functionality of the heart is monitor by examine the electrical activity of the heart. Electrical activity is a primary feature of the heart, and the electrocardiogram (EKG or ECG) is used to monitor this activity. Electrocardiogram (ECG) plays an important role in the diagnosis of heart disorders [54].

The term Electrocardiogram was coined by Dutch scientist Willem Einthoven, who developed the fundamental function of the ECG in 1924 and was awarded the Nobel Prize [74, 89, and 90]. An electrocardiogram (ECG) is a graphical representation that predicts the electrical activity of the heart. ECG test is a simple, risk free and inexpensive. Cardiologists’ use the ECG as a useful tool for diagnoses a variety of heart abnormalities including:

- Heart’s activity
- Electrolyte disturbances
- Physical condition of the heart
- Heart disease [35]

The ECG test performed by connecting wires at arms, legs and chest to see the electrical activity of the heart, and it can be seen on screen or traced out on graph paper. The Electrocardiogram (ECG) test is performing to diagnose and assess the risk of heart problem [35]. In case of any heart problem, ECG helps the cardiologist to know the kind of abnormality in heart. For successful treatment of heart disease, it is necessary to diagnose as early as possible, and this is done with the help of ECG test [37]. The Electrocardiogram (ECG) is the useful tool to measure heartbeat and diagnose CVD. The ECG measures the electrical activity of the heart [6]. Figure 3 shows a normal ECG Cycle (heartbeat) generated by fluctuations in voltage, it consists of following three waves.

**P wave:** - Represents depolarization of both atria

**QRS complex:** - Represents depolarization of the ventricular myocardium
T wave: - Represents re-polarization of Ventricular [66]

Currently, there are a number of options for heart monitoring through ECGs.

Figure 3: - The electrocardiogram (American Heart Ass., “ECG Basics”, 2006)

4.6. Types of ECG

Currently there are two main types of ECG to monitor the heart condition. These are listed below.

4.6.1. Resting ECG

This is also called standard ECG, this is performed in ECG room, the patient lies down on a bed, and movement is not allowed during the test. This type of ECG generally takes 5 to 10 minutes. The disadvantage in this type of monitoring is that, some time, abnormalities of heart may not be detected with standard ECG machines, as it is possible that abnormal condition of heart will not be present at that moment. [53]
4.6.2. Ambulatory ECG

Ambulatory ECG monitoring performs to monitor the heart activity for a long time in order to diagnose the complex heart diseases. In this case, patient is free to go home and perform normal activities while the monitor is attached. This type of ECG is recommended for those patients whose symptoms are irregular and may not appear during a resting ECG test or the patients recovering from heart attack to ensure the functionality of heart. Cardiologist can analyze the recorded data. Currently there are two different types of ambulatory monitors [71,84]

❖ Continuous ECG Recording (by, Holter Monitor)

The most common type of continuous ECG recording is performed by Holter monitor that can continuously record the electrical activity of the heart for 24 to 48 hours. A standard ECG monitors can only record 40 to 50 heartbeats while the holter monitor records 100,000 heartbeats in 24 hours, this help to diagnose complex heart problems [70].

❖ Intermittent ECG Recording

Second type of ambulatory ECG monitoring is the intermittent ECG, such type of ECG cannot be recorded the heartbeat continuously. It records only at that time when symptoms of an abnormal heartbeat occur, which is not occurring very often. The intermittent ECG recording devices have two types [70].

➢ Loop Recorders: - This type of devices may continuously record the heartbeats but it records the heartbeat only when the patient presses the button [70].
➢ Event Recorder: - This device records the heartbeat only when symptoms of the heart problem occur [70].

4.7. Heart Monitoring System

The current heart monitoring system (Holter Monitoring System) has been designed to diagnostic [63] the chronic disease which can become during the activities, such as exercise, eating, sex, stress, movement and even in sleeping [16,85]. However, it is based on short and episodic because it can hold the data of 24 to 72 hours, it only records the heart's electrical activity at that particular time [86]. If the patient is not experiencing symptoms when the test is performed, a heart condition may go unnoticed. Our research work is to propose an intelligent support system for Holter monitoring system that will not only detect the presence of abnormal heartbeat intervals but also issue an alarm message to the remote
monitoring centre. Therefore, the cardiac specialists could respond immediately to save the life of patient.

4.7.1. Holter Monitor

Holter monitor is a wearable and ambulatory ECG monitoring device, which is mostly used to diagnose complex heart diseases, which may appear only during normal activities, such as exercise, eating, stress, bowel movements, or even sleeping [23]. Therefore, to deal with such situations ambulatory electrocardiography (ECG) monitor is a useful tool [64]. Holter monitor can record 100,000 heartbeats in 24 hours which helps to find any abnormality in heart occur during this time period [40]. The first ambulatory ECG device or Holter monitor was analog, tape-based and fully loaded backpack, developed by Dr. Holter in the early 1960s [3].

Figure 4: - Holter Monitor

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Left button</td>
</tr>
</tbody>
</table>
Table 3: - Holter Monitor Description

Each Holter system consists of two basic parts namely.

- The hardware (called monitor or recorder) for recording the ECG
- Software for review and analysis of the record.

Latest Holter monitors have ability to display the ECG signal, which is very useful for monitoring. When the recording of ECG signal is completed (usually after 24 or 48 hours), the cardiologist perform the signal analysis.

The importance of Holter monitor is increasing day by day. A patient can wear the device during his normal daily activity, after 24-48 hour his heart activity can be analyzed by cardiologist to diagnose the type of heart disease for suitable treatment. [56] Holter Monitor is a useful prognostic tool of heart rate monitoring. [15]. Holter monitor can also be useful for elderly patients whose heart rate gradually decreasing, this will also help to reduce the hospitalization costs for elderly heart patient [45].

4.7.2. Application of Holter Monitor

The main application of Holter monitoring is to document and identify occurrences of abnormal electrical activity in the heart. Cardiologist uses the Holter Monitor to diagnose the heart disease in the fallowing cases [31, 56, 15, and 45].

1. To diagnose the irregular chest pain not appears often
2. When complex heart diseases which cannot be diagnose through resting ECG test, holter monitor is the best option to capture any abnormal heartbeat during the period of 24-48 hours
3. To diagnose such signs and symptoms which may be reason of heart-related problem, such as fatigue, shortness of breath, dizziness, or fainting
4. To identify and evaluate the irregular heartbeats or palpitations
5. To evaluate risk for future heart-related events in certain conditions, such as enlarged heart due to unknown reasons
6. To evaluate the functionality of an implanted pacemaker
7. To find out the effectiveness of therapy for complex arrhythmias

4.7.3. **Shortcomings in Current Holter Monitors**

Although the current holter monitor is the best device for heart monitoring but through systematic literature review, we found out the following shortcoming.

1. While Holter monitor is a portable heart-monitoring device, which record the ECG for 24 to 48-hour, which are analyzed later offline. The major shortcoming in holter monitor is that, in case of acute situation of heart abnormality it has no capability of providing any real-time alert. In the case of acute situation of heart abnormality, Holter monitors are not a life saving diagnostic tool because it simply record the heart’s activity and provide no any warnings.[43]

2. The accuracy of data, get from holter monitor, depends upon the daily activities and symptoms detailed diary [41].

3. During monitoring the functionality of implanted pacemaker. It is not possible in current heart monitoring system (holter monitor), any real time feedback, and in case of any fault or stop of pacemaker, which is dangerous for patient.

4. Holter monitor’s heartbeat recording period is not sufficient(24-48 hours) to diagnose complex heart disease, may be day after test completion, symptoms occurs [56].
5. **Empirical Study/Case**

The empirical study/case for our research work has been discussed in this chapter that describes the case for proposed system. Therefore, we have conducted survey-I, survey-2 and interviews to obtain the required data for our research work. Survey-I was conducted from five respondents including one doctor and four heart patients. The respondents for Survey-2 were twenty heart patients from different areas e.g. Sweden and Denmark. Eight medical personnel were selected to conduct the interviews from Sweden, Denmark, China and Pakistan. The selected interviewees had relevant experience and expertise related to heart monitoring system.

### 5.1. Case

In this section, a scenario is described to design an IDSS base Heart monitoring system for elderly heart patients. This monitoring system will be appropriately used in a department of cardiology. Every day a number of heart patients are examined in Karlskrona hospital and admitted for further diagnosing. Some are allowed to go home with holter monitor to monitor the heart condition during his/her daily activities.

While the patient busy in his/her daily activities, sometime her/his heart rate exceeds the maximum threshold allowed, that becomes cause of heart attack. The current heart monitoring system (Holter Monitor) only records the ECG. This situation of the patient may lead to death. Our proposed system, during ECG monitoring, will detect any real time emergency situation (heart rate exceeds the maximum threshold) and will send an alert to medical personnel for an immediately first aid.

### 5.2. Proposed System

In order to handle critical situation of a heart patient and to overcome the shortcomings, find out through literature review and survey-I, we propose an Intelligence Decision Support system, for heart monitoring system. This system will create a real time alert in case of worse situation, during ECG monitoring. The design of this system will specifically help the elderly heart patients, who are under treatment at home. Now we describe the system in detail.
5.3. Overview of the Proposed System

The proposed heart monitoring system comprises of four main parts - namely

- Bluetooth enable Holter Monitor
- Bluetooth
- Data Acquisition Module
- Computer-base IDSS

Figure 5: - Overview of the system
The functionality of each one of the components of the proposed heart monitoring and alarming system and the detail regarding their implementation described in the following sections.

5.3.1. Bluetooth Enable Holter Monitor

The Bluetooth enable Holter Monitor is not limited to just recording ECG but also has functionality to transfer ECG data via Bluetooth simultaneously to intelligent decision support system [91].

5.3.2. Bluetooth

Bluetooth technology is a short-range wireless communications technology. This technology has vast use ranging from mobile phones and computers to medical devices and home entertainment products. The key features of Bluetooth technology are simple, secure, robust, low power, and low cost [69, 91]. In proposed system the functions of Bluetooth transfers data from holter monitor to DAM.

5.3.3. Data Acquisition Module (DAM)

The main function of DAM is to acquire patient’s ECG data from holter monitor through Bluetooth. The ECG signal obtained by the DAM is in the range of 1 to 5mV. Due to weak voltage level of the ECG signal, there is need to amplify for analyzing purpose. DAM also performs this function. The amplified signal is then fed into the ADC circuit for A/D conversion [18]. This processed ECG data is send to computer based IDSS system.

5.3.4. Intelligent Decision Support System

Our proposed system is an efficient mechanism for real time alert for heart monitoring. Our proposed system helps the cardiologist to notify promptly when abnormal condition occurs. IDSS is proposed for this functionality. The proposed heart monitoring system enhances the functionality of current heart monitoring System (Holter Monitor). The heartbeat generated by heart monitored by holter monitor. These heartbeats can be sent through the wireless devices (Bluetooth) to our proposed intelligent decision support system (IDSS) via DAM.

In IDSS the heartbeats analyzed and in case of abnormality and alarm is generated, which is received by Cardiologist, Nurse or Emergency depending upon the degree of abnormality.

IDSS is inherited from DSS [62] that uses different intelligent techniques to solve the real world problems and find out the most optimal solutions. There are different kinds of multiple IDSS, which include
IDSS that replace the existing model

IDSS where the functionality is added to enhance the existing model in order to make it intelligent [22]

In the context of our research, we proposed the second model of IDSS, which enhances its functionality. It has the ability to improve and increase its analytical capabilities. Normally IDSS has a large number of options to analyze the problem and has to decide among the options in short time [62].

5.4. Decision Support System (DSS)

Decision support system is an important computer-based tool. The main purpose of DSS is to support and improve decision making [19]. DSS support in complex problem solving mechanism and assist the human to make better decision. In health-care, such systems used to improve the quality of health-care, with the possibility of reduction of hospitalization cost without loss of quality. Successfully implemented DSS can help to diagnose the complex diseases and save the time for an optimal decision. Decision Support System is a general term, which can cover all types of systems in the field of health-care [60].

5.5. Architecture of IDSS

The ECG signals from holter monitor are detected by detector, and separated into normal and abnormal heartbeats. Normal heartbeat stored in database and abnormal heartbeat stored in buffer zone for 30 second. Abnormal heartbeats are then analyzed by analyzer. Alarm generated depending upon potency of abnormality. In the architecture of the IDSS for elder heart patients, different functions of holter monitor e.g. monitoring; storing and alarm are integrated without disturbing each other. An integrated architecture is useful for the system. Therefore, the system can be efficient and consistent [4].

The use of intelligent decision support systems (IDSS) in holter monitor will make it more efficient and intelligent. The care giver will be able to quickly gather information and process it in various ways in order to assist the elderly heart patient in some severe situations. IDSS will also enhance the functionality of current Holter Monitor.
The Intelligent decision support system in Holter Monitor will monitor the heart activity in case of any abnormality. It will pass an alarm to Nurse, Cardiologist or Ambulance depending upon the type of abnormality. In this way, the patient will be treated in time and will be saved from complex situation. Therefore, the system will help to save from complex condition of heart patients and reduce the treatment cost as well.

5.5.1. ECG Receiver

The main function of the ECG Receiver is to receive the ECG data from DAM via wireless. After receiving the ECG data, it will be sent to the ECG analyzer for analyzing the ECG.
5.5.2. **ECG Analyzer**

The electrocardiogram (ECG) interprets the electrical activity of the heart and is the most important data to investigate heart diseases and conditions. In each ECG cycle, QRS Complex, S and T wave are the feature points with physiopathological significance. These points show the action potentials of different chambers of heart [58].

- P wave corresponds to the contraction of the atria
- QRS complex (composed by Q, R and S wave) corresponds to the contraction of left ventricle
- T wave corresponds to relaxation of the ventricles

Hence, it is possible to find out the heart condition and degree of disease of the patient based on the features of ECG signal. The fuzzy method is the appropriate method for classification of ECG. Hence, the fuzzy ECG classifier is used in proposed heart monitoring system [7, 25, and 29]. The fuzzy ECG classifier is comprised of two major function blocks, ECG Parameterizer and Fuzzy classifier as shown in Figure 7.

The ECG Parameterizer block is used to detect the characteristic points, including P wave, QRS Complex and T wave, of ECG signal base on the method of Wavelet Transform (WT). The derived parameters including amplitudes and durations will be sent to the second block fuzzy classifier for classification of ECG. The level of abnormality of heart will be determined. The signal depending upon the level of abnormality will be generated by alarm system.

![Figure 7: ECG Analyzer](image-url)

Figure 7: - ECG Analyzer
5.5.3. **Alarm System**

The main function of alarm system is to send the information of heart beat to the Doctor, Nurse or emergency staff according to level of abnormality. If abnormal heart beat found but condition is not worse than signal will be send to heart nurse to see the patient. In case of the abnormality is alarming than the signal will be sent to the doctor to see the patient. If the abnormality is worse than the alarm will be sent to ambulance to treat the patient immediately.

5.6. **Key Features of the proposed System**

The system would be easy to operate, easy to transport and would be used to real time monitor of elderly heart patient. Benefits of the device include:

- System will generate real time abnormality alarm during cardiac activity of heart patient
- Proposed Holter Monitor will safe, inexpensive and will provide valuable diagnostic information to health professional
- Patient treatment cost will be reduced by using this system
- Easily accessible
- User friendly
- Portability
5.7. Questionnaire/Survey

Questionnaire or survey is systematic method to collect the data from population of interest and it is comparatively convenient and inexpensive method and it tends to be quantitative in nature [88].

5.7.1. Advantages of Survey

Survey is used to collect the quantitative data/information and closed ended questions can be used to measure the participant’s perceptions, their opinions, attitude, and their knowledge, behavioral and behavioral intentions [88]. The advantages of questionnaire are

- Comparatively minimum time consuming frame
- Can be minimized the biasness through Standardized and structured questionnaire.
- Incredible volume of information can be gathered with in short period [88]

But on the other hand it has some drawback that sometimes it can be expensive and it required statistical knowledge and specialized skills [88]

5.7.2. Planning of Questionnaire

Before doing the questionnaire, it is very important to keep in mind that which step you will follow to get a better result from the respondents. Therefore, the following steps have been used before conducting the survey [88].

- Explicate the purpose
- To assess resources
- Decision about methods
- Writing the questionnaire
- Revise the questionnaire
- Sample preparing
- Training interviewer
- Data collection
- Data Processing
- Result analyzing
5.7.3. Questionnaire Designing and Distributing

We have used Likert-type scale for questionnaire with our respondents because in this method they mention their level of satisfaction or dissatisfaction on a systematic satisfy-dissatisfy scale [14], [87]. We did not use open ended questionnaire because some time patients also hesitate and feel difficult to give their own opinion and it also time consuming.

5.7.4. Survey-1

In order to make the validation of the problems and shortcoming (See chapter # 4, section 4.7.3) extracted from literature review, we have conducted survey–1. This survey helped us to know about the problems of heart patients regarding the usage of heart monitoring system, unusual visits of health care centers due to the current heart monitoring system, effectiveness of holter monitor and the need of IDSS based heart monitoring system[60], we have planned to conduct a survey from the respondents (See table 4:- Respondents in survey-I).

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Less than 45</td>
<td>1 (d)</td>
<td>1</td>
</tr>
<tr>
<td>45 and above</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4: - Respondents in survey I

Due to the survey, we can collect the maximum information within a minimum time period. The advantage (see Chapter 5, section 5.7.1) of conducting the survey tends us to adopt this method to collect the data to make our research more valid and effective. Some steps (see Chapter 5, section 5.7.2) should be kept in mind before conducting a survey.

The questionnaire was designed with close ended questions (See Appendix – A) according to Likert scale method (See Chapter 5, section 5.7.3) in which closed-ended questions predefined the answers e.g. “YES”, “NO” or multiple choice (See Appendix-A). Therefore, it is an easy way to find out the quantitative results. After a short conversation about our
topic, the respondents filled out the questionnaire according to their opinion and returned to us with useful information. The respondents were much familiar with the heart monitoring system, which already has been used for their health analyzing (See APPENDIX-A, Q1).

5.7.5. Survey-II

In order to get the feedback about our proposed system, we have conducted the survey-II with heart patients that concerning how much the new proposed system will be affected to overcome their problems and for saving their lives in case of any emergency. To achieve our goal, first of all, selected 20 patients from form different areas of Blekinge County, Karlskrona hospital Sweden and Rigshospitalet Copenhagen, who have already been used Holter Monitor during their heart disease.

We gave a short overview about our research and proposed heart monitoring system and then distributed the hard copy of questionnaire (see sample questions in appendix B) to get their opinion. The languages used to express the questions were English, Swedish and Danish. The participants, their age; disease duration and sex are described in the table “Total No of patients who have participated in survey-II”. The selected participants filled out the questionnaires and provided us with useful information.

<table>
<thead>
<tr>
<th>Age</th>
<th>Disease Duration</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25 Years</td>
<td>1-5 Year</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>26-50 Years</td>
<td>5-15 Year</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>15 &amp; above</td>
<td>7</td>
</tr>
<tr>
<td>51 and above</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 5: - Total No of patients who have participated in questionnaire

To collect the data and information for analyzing the research work, questionnaire plays an important role because it is comparatively convenient and inexpensive method. Therefore, we designed closed-ended questionnaires (see APPENDIX - B) to collect useful information to make more convenient the heart monitoring with new invention. Predefined answers e.g. “YES”, “NO” or multiple choice for selection can be given with the questions. It makes it
.easy to obtain the result for analyzing the quantitative results. We visited health centers in Karlskrona Sweden and Rigshospitalet, Copenhagen to contact with the heart patients.

5.8. Interviews

Interviews plays an important role to collect such type of qualitative data, which cannot be accessed while using the other techniques i.e. literature review, observations and questionnaires [88]. The point of review to conduct the interviews may be different, but it is a very good method to analyze the research for its validation. Interviews can be conducted either face to face, telephonic, email or through Skype. We have adopted all of the above methods to conduct the interviews. We contacted interviews from the doctors and medical specialist from Sweden, Denmark, China and Pakistan and discussed about our research area to collect the information through structured questions (see APPENDIX-C). To achieve our purpose we planned to conduct the structured interviews including the both open-ended and close-ended questions. Information about Interviewees is described in the table (See table Information about interviewees). After a short introduction about our IDSS based holter monitor for heart patients, there become a session of questioning and answering about the research area.

5.8.1. Interviews Purpose

The author conducted the interviews with experienced medical staff to validate result for effectiveness of IDSS based Holter Monitor. Due to conducting the interviews from medical staff, the authors were able to have some detailed information about the systems, which is being used for heart monitoring. The authors gathered the opinions and suggestions for IDSS based heart monitoring system (Holter Monitor) from the expert persons. This information gathered through the interviews may be helpful to get better result for saving the lives of elderly heart patients.

5.8.1. Interviewing

Interviews were conducted face-to-face, telephonically and online on Skype with respect to the geographical distribution. The duration of interviews was about 35 to 40 minutes. Before asking the questions from the interviewees, a short description of research topic was presented. During the interviews, important points were written down on the paper. The collected data/information was transcribed and important points were separated from the discussion. The transcribed form of the data gathered during the interviews can be viewed in APPENDIX-C.
5.8.2. Interviewees

For the verification and validation of our proposed system, we have conducted eight structured interviews with different medical specialists from different countries (Sweden, Denmark, China, and Pakistan). We conducted the interviews face-to-face, telephonic and Skype. The authors have included the medical specialist from different major hospitals because they thought that due to the good experience of the doctors, we will able to get the most suitable information to analyze our research in a better way. The detail of interviewees is given in the below table no 7.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name</th>
<th>Department, Country</th>
<th>Interview Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. Bjorn Eklund</td>
<td>Blekinge Hospital Karlskrona, Sweden</td>
<td>Face to face</td>
</tr>
<tr>
<td>2</td>
<td>Dr. Farzana Yousuf</td>
<td>Blekinge Hospital Karlskrona, Sweden</td>
<td>Face to face</td>
</tr>
<tr>
<td>3</td>
<td>Dr. Jesper Hasterup</td>
<td>Rigshospitalet, København, Denmark</td>
<td>Face to face</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Adil Rashid Cheema</td>
<td>China</td>
<td><a href="mailto:archeema99@skype.com">archeema99@skype.com</a></td>
</tr>
<tr>
<td>5</td>
<td>Dr. Syed Imtiaz Hussain</td>
<td>Rawalpindi, Pakistan</td>
<td>0092-345-64 68 429</td>
</tr>
<tr>
<td>6</td>
<td>Dr. Nadia Minhas</td>
<td>National Hospital Lahore, Pakistan</td>
<td><a href="mailto:mtminhas@skype.com">mtminhas@skype.com</a></td>
</tr>
<tr>
<td>7</td>
<td>Sidsel Lauritzen</td>
<td>Medical Specialist, København, Denmark, 35395893</td>
<td>Face to face</td>
</tr>
<tr>
<td>8</td>
<td>Ea Lorcutzen</td>
<td>Head Tech, Heart Department, Rigshospitalet, København, Denmark</td>
<td>Face To Face</td>
</tr>
</tbody>
</table>

Table 6: - Information about interviewees
To analyze the result in the research work, interviews plays very important role. It was very helpful for us to verify and analyze the research work for validation with interviews. The expected information about our proposed IDSS based heart monitoring system was gathered and it was very good response from the doctors.
6. RESULTS

6.1. Survey-I

Three respondents have suggested that there should be a real time heart monitoring system to save the lives and the recording capability of the heart monitoring system should be extended. According to the respondents, heart monitoring system (Holter Monitor) gives the accurate and efficient result but it has some flaws which should be filled. They responded that in some extent the current heart monitoring system is not fully supporting in case of acute situation. It does not transfer any data or message to the medical specialist about any abnormality in a real time. The data gathered through the question (See APPENDIX-A, Q3) expressed that the patients don’t fully satisfy because it does not support in case of any emergency. The accuracy of data depends upon the daily report of activities and symptoms in detail.

![Satisfaction level in case of emergency](image)

Figure 8: - Satisfaction level in case of emergency
They also gave their views about the recording period of the current heart monitoring system. It was judge in lieu of the data gathered from the survey that there exists a drawback that the current heart monitoring system has very less recording period up to 48 hours.

If the holter monitor dairy sheet is not completed properly, there might be some percentage of error in analysis. So the dairy should be maintained properly. But some time patients forget to write down the symptom and time of occurrences. Suggestions from the respondents are as under (See APPENDIX-A, Q6)

- To have ability in real time scenario
- Recording period should be extended
- Dairy should not be maintained

![Effectiveness](image)

Figure 9: Effectiveness, while evaluating the functionality of implanted devices
In the current holter monitor, the patients have to maintain the diary sheet regarding the time and date in case of any emergency. It was asked from the patients in the survey (See Appendix-A, Q-6) that how much you satisfy to maintain the diary. Most of the respondents gave their views (See figure 10) that they were not satisfied to maintain the diary because sometimes they forget to write the exact time and date.

![Holter Monitor Diary Sheet](image)

Figure 10:- Holter Monitor Diary Sheet
6.2. Survey-II

For our research work we have conducted the questionnaire with twenty heart patients (See Table 5: - Total No of patients who have participated in questionnaire) in order to know their information about the current heart monitoring system, its effectiveness and need of IDSS based monitor. We also came to know that what are the opinions and suggestions of the heart patients about our proposed IDSS based heart monitoring system. Therefore, we conducted a survey and described about our proposed system and distributed a questionnaire to the heart patients. They filled out the Performa of questionnaire according to their opinion and returned back to us with useful information (see APPENDIX - B). The designed questionnaire along with data collected from heart patients is described in APPENDIX – B, and on behalf of the collected data, statistical analysis has been made.

According to the patient’s feedback about the usage of current holter monitor, different respondents gave us different information. In APPENDIX – B, Q1 shows that how many patients have used the heat monitor in how many times during their disease.

![Patients used Holter Monitor](image)

Figure 11: - Patients used Holter Monitor
It was analyzed that a number of patients know about the holter monitor because they have already used in different times. It was noticed that there were three patients who have used holter monitor for five times and there were five heart patient who used the current heart monitoring system for four time, which means that 15%+25% = 35% of the whole respondents have enough usage experience. Therefore with the feedback from the above mentioned percentage of heart patients, will give us strong evidence for our proposed system. The patients who have used the current heart monitoring system can be expressed through the given figure that is figured according to the data received from the patients.

It was also noticed that the patients have enough knowledge about Holter Monitor because they have used it for a sufficient number of times which has been shown in (see APPENDIX – B, Q1 and figure 5: –Patients used Holter Monitor).

![Patients familiar with current Holter Monitor](image)

Figure 12: - Patients familiar with H. M

According to the information received from our next question (see APPENDIX – B, Q2). There was enough number of heart patients who were much familiar with current heart monitoring system (Holter Monitor). There were 8 participants out of the twenty, who said
that they are much familiar and 5 patients gave us the information that they were very much familiar with the current heart monitoring system. It meant that there were a large percentage of the respondents \( (25\% + 40\% = 65\% ) \) who showed their familiar level is very much.

It became very plus point for us to collect the data from devise familiar persons because the patient can rephrase about the devise more effectively than the other patients who don’t know about the heart monitoring system. Patients familiarity level with the current holter monitor is presented through the figure (figure 6: - Patients familiar with Holter Monitor), which is based on the data collected from the respondents against APPENDIX –B, Q2.

A good familiar of Holter Monitor, can give the best feedback on the current heart monitoring system. According to the data (see Appendix – B, Q3) which has been collected, shows that only 5\% of the total patients, who have participated in survey, were most satisfied with the current holter monitor and 15\% of the participant were explained that much satisfied with the functionality of the current holter monitor. Three respondents out of twenty fill out the questionnaire with their opinion that they don’t satisfy with the current holter monitor.

The opinions of the respondents have been figured out (see Figure 13: - Patients satisfaction level) while collecting the data/information which has been received against the question (see Appendix – B, Q3) for patient’s satisfaction on current holter monitor.

![Patients satisfaction level](image)

Figure 13: - Patients satisfaction level
Respondent’s satisfaction level on the current holter monitor shows that they already not satisfied with the current functionality and they were thinking to have such kind of heart monitoring system, which could be according to their expectations some patients who replied that they are not satisfied because it takes a time to analyze their heart status. They have a threat that in case of any abnormality. Therefore, it was a need of time to have a new IDSS based heart monitoring system, which could fulfill the expectations of heart patients and could have the facility to meet the future challenges.

For the efficiency level of recording functionality in Holter Monitor, (see APPENDIX – B, Q4) 10% of the participant expressed totally disagreed but on the other hand 20% of the participated patients, were total agreed with the efficiency level of the current holter monitor. Fifty percent (20% + 30% = 50%) of the total respondents, (10 patients) were agreed with the efficiency of the current heart monitoring system, but 10% + 15% + 25% = 50% participants were disagree or limited agreed. They told that it has very good efficiency level for its recording the data but fifty percent had the opposite views. The data gathered through the question is described in figure (figure 14:- Efficiency level of Holter Monitor).

![Efficiency level of Holter Monitor](image-url)
There are more than fifty percent patients out of twenty patients, who were disagreeing with the efficiency of the current holter monitor. In lieu of above mentioned remarks, concluded from the data gathered through the question (see APPENDIX – B, Q4) it can be judged that it is a need of new heart monitoring system which could have the ability for recording as well as the data transfer facility in the real time to save the lives in case of any abnormality. Therefore, our proposed system can have such kind of ability and efficiency to meet the future

Although the current heart monitoring system (Holter Monitor) is very good and it helps to analyze the heart beat and other heart disease but according to the survey, (See APPENDIX–B, Q5), 35% of the total respondents gave their opinion to have alarming system. 20% respondent strongly recommended in favor of alarming system and there were only 5% of the participants, who were not in the favor of new alarming system. Participant’s satisfaction level has been expressed through the figure (See figure 15:- Alarm in Holter Monitor)

![Satisfaction level for Alarming System](image-url)
It means that the patients were agreed that due to the alarming system in current heart monitoring system, the threat will be reduced and patients will live without any tension. There were a large number of patients who suggested that the alarming system will be need of future.

We also met a patient who was heart attacked and could not inform to the doctor, his pacemaker was also shut downed due to out of ordered, and another person called for ambulance. He also said that once there was heart attacked during his sleeping timing and by the grace of God, he remained saved. So he was strongly recommending that the alarming system is very good idea to save the lives during such conditions.

Through the questionnaire (See APPENDIX-B, Q6), when we asked about the proposed system is a better solution than the current heart monitoring system then 30% of the participants were favor of the proposed system and 35% of the respondents were also much agreed that the new system will be the better solution as compared to the existing heart monitoring system. There was only little number (5%) of the participants who gave their opinion, which was against the new system.

![Better solution as compared to Holter Monitor](image)

Figure 16: - Better solution as Holter Monitor
This recommendation for better solution as compared to current holter monitor has been shown in figure 16, Better solution as Holter Monitor. It shows that the patients agreed that in future, it would be good sign to save the life during crucial time. The patient to whom we have already discussed, strongly recommended the proposed solution and said that it will be the best option to save the patients without any delayed, whenever they have any abnormality in their heart disease.

It was a very large number of patients who were agreed that the proposed solution will be the best solution to save life and time. The collected data is mentioned in (See APPENDIX-B, Q7). Through this question, it shows that 40% of the participants strongly recommended that due to the new proposed heart monitoring system life and time can be saved because patients don’t want to have any risk for their life. There were only 5% (See figure 17:- Life & time saving with proposed system) of the respondents who were not agreed with the new proposed system. It was their own opinion, and everyone has right to give his views but the large no (25% + 40% = 65%) of the respondents were in favor of our proposed system.

![Life & Time Saving with proposed system](image)

Figure 17: - Life & time saving with proposed system
It means that the new proposed system will have the capability to save the lives in case of any emergency. The care giver would be able to provide medical treatment when they will receive any alert from the system.

From the data received against the question (See APPENDIX-B, Q8, Q9), it can be expressed that the IDSS based proposed system will be the best solution as compared to the current heart monitor in case of emergency. It will be the best option to save the time and money while reducing the unusual visits of the heart patients to their doctors and health care centers. Therefore, it can be concluded that after implementation, the proposed system will have the ability to make the heart patients with threat free and risk free life.
6.3. Interviews

We have collected the data according to our questions during the interviews session (see APPENDIX-C). The answers of the each question from the doctors were, in the form of opinion, suggestions and different satisfaction level according to the questions designed as Likert scale. The information was noted down during the interviews. The authors were satisfied from the interviewees because we thought that the interviewees have given us their opinion in the form of information for each questions. It was fully appreciated from the medical staff that our proposed system would be a very good solution for heart monitoring system in future.

The information was collected such as current heart monitoring system and its effectiveness, and in what extent the care givers as well as the patients are satisfied with the current heart monitoring system. During the interview session it was also come to our notice that there were around about 1100 heart patients in the county of Blekinge and around about 1500 people were heart patients in København Kommune.

The interviews session was very helpful to analyze the proposed IDSS based heart monitoring system, which would be better achievement for elderly heart patients. The questions, which were asked during the interviews, have been mentioned in appendix-C. During the interviews Dr. Farzana Yousuf also told that there are 1100 heart patients in the county of Blekinge, who have been used Holter Monitor. She also told that, from the above mentioned figure of the patients, the most patients are elder people.

During the interviews session, medical specialists told that the current heart monitoring system is very helpful to diagnose the heart disease. During the discussion with the doctors, it was also come to our knowledge that that although Current heart monitoring system is very much helping but it gives us the results on momentary basis. On the other hand some of them told that the current heart monitor is very good invention but it gives us a data for a specific time period because this system records the information for a specific time e.g. 24 to 48 hours (see collected data in APPENDIX-C, Q1). According to the doctors viewpoints in current scenario the ability of holter monitor to diagnose the heart problem is very good.

It was also noted that the current heart monitoring system (Holter Monitor) has enough satisfactory ability to monitor the heartbeat and provide the information, of a specific time period, for analyzing. The collected data (see Appendix-C, Q2) shows that due to the current system, we can get satisfactory result for analyzing the patient’s condition. During the interview concerned told that it is better than the previous ECG devices. Therefore we are
much satisfied with it result. However, it was also come to our knowledge that due to non-provision the information in real time scenario, some of them was not so much satisfied.

Although the current system gives the satisfactory result and help to diagnose by analyzing the recorded information but in case of emergency it does not support to cover-up the real time problems. Elderly have to visit to their hospital or doctors for analyzing the recorded data and on the other hand in case any problem, patient has to write-down time, activity and symptoms on the diary sheet (for sample see APPENDIX-E). It was also noted that some elderly are not so much satisfied because they want to have such type of system, which could help them automatically in case of emergency. Therefore, there may be also some threats in the mind of elderly people that during the attack at the time of sleeping there would be difficult to save them.

When it was discussed with the medical specialist about the cause due to that elderly are not satisfied with the current heart monitoring system. They gave their opinion (see APPENDIX-C, Q4) and told that why are elderly not satisfy with the current heart monitor. Some main causes are, as under due to those some don’t have extremely satisfaction with the current heart monitoring system.

- To maintain activity report (diary sheet, see Appendix-E)
- Forget to write on diary
- Current heart monitoring system don’t support in real time
- Some time it happens that during sleeping, a patient is alone and can’t contact with the doctors therefore it might be some patients are not so much satisfied.
- In Pak, due to un education elderly could not maintain diary
- Unnecessary visits

In the interview sessions, when it was asked about the implementation of our proposed IDSS based system, the medical specialists appreciated and showed their interest. They agreed (see APPENDIX-C) with our proposed system and told that of course it will be very good achievement for elderly heart patients. The concerned doctors told that in new era everything could be made possible with information technology. Therefore, IDSS based proposed system (heart monitoring system) will fulfill the future requirements to enhance capability to save the lives of elderly heart patients. Through the proposed system, the real time message or alert will be generated in case of emergency and it could be possible to reach for patient
help. On the other hand, the proposed system will also make it possible for the doctors to get easy access to the heart patients in case of emergency. It was also concluded through the interviews that through the proposed system unnecessary visits could be also reduced (see Appendix-C, Q6 and Q7).

6.3.1. Graphical Representation of Collected Data

Through the doctors point of views the cost for hospitalization could also be reduced while using our IDSS based Holter Monitor. The data gather from the doctors viewpoints have been represented in the given graph.

![Graph of respondents showing cost reduction](image)

Figure 18: - Reducing the cost for hospitalization
The above graphical presentation can also be illustrated through mathematical to prove that mostly have given their opinion in the favor of IDSS based heart monitoring system.

Strongly disagree = 0% effect = 0%

Strongly agree = 25% effect = 25%

Neither agree nor disagree = 25% effect = 0%

Tends to disagree or agree = 12.50 - 37.50 effect = 25% (tends to agree)

Therefore, it can be concluded that 25% of the total doctor were strongly and 25% were tends to agree with our proposed system that it will reduce the hospitalization cost.

It has also been noted through the doctor’s opinion that the proposed system will improve the result and will make it efficient and rapid than the current heart monitoring system which is presented in the given graph.

Figure 19: - Result improving and efficient
When we discussed about the proposed system, that how much it will save the patients lives and time, the concerned medical staff gave their opinion that is presented here through mathematical and graphical view.

Strongly disagree = 0%

Strongly agree = 37, 50%

Effect in strongly agree = 37, 50% - 0% = 37, 50%  \textbf{effect = 37, 50%}

Neither agree nor disagree = 12, 50%  \textbf{effect = 0%}

Tends to disagree or agree = 50% - 0% \textbf{effect = 50% (tends to agree)}

Therefore, it can be concluded that 37, 50% of the total doctor were strongly agree and 50% were tends to agree with our proposed system that it will save the lives of the patients and time as well.

![Respondents](image)

Figure 20: - IDSS based H.M will save lives, time and extra ordinary visits
Intelligent Decision Support System based Holter Monitor, will be the better solution to monitor the heart disease in future. Figure 21 explains the views of the respondents about the proposed system (see Appendix - C).

![Respondents](chart)

Figure 21: IDSS Based System will be better solution in future
6.4. Co-Relation on the Findings

The co-relation based on the findings from survey-II and interviews is graphically presented as below. Respondents of survey-II and interviews replied in the favor of IDSS based heart monitoring system (See Appendix-D).

6.4.1. Proposed system as better solution

According to the results gathered from the respondents (see Appendix- D), the proposed system will be the better solution in future. Figure 22, shows about the co-relation of the result from interviews and from the survey-II.

Figure 22: - Co-relation- Better solution
6.4.2. Proposed system for life and time saving

Figure 23: Co-relation - Life and time saving

(See, Appendix-D)
7. **DISCUSSION/ANALYSIS AND VALIDITY STATEMENTS**

7.1. **Discussion/Analysis**

Heart disease is a major cause of death in the world, especially in elderly people. Heart diseases affect the elderly people in large scale. Heart monitoring system for elderly people is big challenge in developing and developed countries. Currently there are two broadly applicable systems for heart monitoring, ECG data recording and analysis. First, is a real-time recording of ECG during patient examination at hospital and second is a 24-48 hour ECG recording with a post analysis called Holter monitoring. The weakness of the first method is that it is not possible to have the complete diagnosis, which often requires more monitoring and recording than a single ECG recording. The inadequacy of the second method is that it is not possible to inform concerned medical staff immediately in emergency, which sometimes can have severe consequences. Moreover, the analysis accuracy of the recorded ECG data mostly depends upon the patient diary.

Our proposed system is an intelligent decision support system based heart monitoring and alarming system for elderly heart patients living alone at home. We are able to detect life-threatening heart abnormality in time. Through IDSS based proposed system, we can make contact with an ambulance, doctors, and medical staff respectively according to the condition of the heart patient. However, in normal situations, our system is capable of monitors and records the ECG data for further analysis by specialist. This analysis will be helpful to know the condition of the patient.

Our focus group is elderly heart patients that have had a heart attack, or are at high risk and have sometime heart problem not clearly. We learned from discussions with cardiologists that these patients are worried that a heart attack will occur again. They are very impressed with our concept and agree with our proposed system. We have learned from discussion and survey with heart patient, that our proposed system more helpful in emergency situation and also to check the functionality of implanted devices like pacemaker. The patients are worried, that current heart monitoring system is not much effective in severe situation. They are facing problems with current heart monitoring system, when they undergo to check the functionality of pacemaker.
Fuzzy based ECG classifier proposed for heart monitoring system, which is more suitable. ECG signal is very sensitive and have complex parameters, in order to analyze the ECG more accurately. In fuzzy logic, we measure the value between 0 and 1. Therefore, fuzzy based classifier, classified the ECG signal into four categories, Normal, abnormal-1, abnormal-2, abnormal-3 [See chapter # 5, section 5.5.2, figure 7].

In order to validate the concept, we have conducted the survey with heart patients from Sweden and Denmark [see chapter # 5, section 5.7] and interviews with concerned health professional from Sweden, Denmark, China and Pakistan [see chapter # 5 section 5.8]. The result obtained from survey with heart patients shows that, proposed system will play important role in heart monitoring field. The patients feel strongly agreed with our proposed system. We conduct interview with related health professional not only from Sweden but also from other countries for more evidence to validate our research work. There is a big scope of future work regarding our thesis.

During the interviews when we described about the proposed heart monitoring system all the respondents had appreciated our effort for elderly heart patients. They encouraged us and promise to support in any kind of information related to our research in future. They said that with the existing system patients come to the doctors and then they are examine after analyzing the data received from current heart monitoring system, but due to the IDSS based system the doctors will be able to monitor the current condition of the patients even if they are at their homes. The doctor will have enough time to save the patient’s life in any abnormalities.

Through the interviewees, it has also come to notice that the IDSS based system will help a lot to the both medical staff as well as to the heart patients. It will also be helpful to make any decision for patient’s health. Due to this system care providers will able to monitor the current heart condition of the patients and also the previous abnormalities which had been occurred, only by using the patients identification number or name. It will also reduce the unnecessary visits of the elderly patient to the doctors. It will more satisfy to the patients because they would be able to be helped with in short period of time, in case of emergency.

### 7.2. Validity

Validity of a research has an important role for the credibility and accuracy of the findings and outcomes of a research work. Validation is very important the research work is either
7.3. Validity Threats

Validation is important for the both type of researches, qualitative or quantitative and their credibility and accuracy have been decided by the reader’s opinions and suggestions. Different validation threats have been proposed by the different authors but may have similarity in some type of descriptions. It has already been described that the authors have used exploratory case study for their thesis work. Therefore, the proposed system has been evaluated from questionnaires and interviews, where qualitative data has been produced collectively in the form of observation, satisfaction level, assent level appreciation, opinion, discussions and suggestion. The observation and measurement of anything is concerned with the intentions i.e. “whether we are measuring what we intend to measure or with how our observations are influenced by the circumstances in which they are made” [61].

William M.K. Trochim has presented four different criteria’s to analyze the significance of research and to evaluate the validation, which we have used for our thesis work.

- Credibility
- Transferability
- Dependability
- Confirm ability

A brief description of the above validity threats with respect to the implementation in our research work, is being described in the following section

7.3.1. Credibility

Credibility criteria are used to analyze the credibility and effectiveness of the results in our thesis that is produced by the qualitative research. Credibility criteria also highlight the opinions about the outcomes of research work, given by the participants. Due to the exploratory case study, we have started our research work from literature review (See chapter # 4, Systematic Literature Review). We have used many resources such as research
articles, journals, books, conferences and reports, web information, related to our thesis work.

After then we have proposed IDSS based heart monitoring system (See chapter # 5, section 5.2, proposed system). We have presented the proposed system in front of twenty heart patients (see table 7) from different hospital in the form of questionnaires (se chapter 6, section 5.1). We have also conducted eight interviews form experienced medical specialist from different countries i.e. Sweden, Denmark, China and Pakistan to make our research more credible (se chapter 5, Section 5.8).

The main purpose to conduct the questionnaires and interviews was, to evaluate the result of our proposed system. Views, feedback and suggestions were gathered by doing the questions in questionnaires and in interviews, which were designed in a simple language for easy understanding.

7.3.2. Transferability

Transferability can be dealt with the degree, to which applications of the results in qualitative research may be generalized. So for this, different possibilities of the thesis with respect to the transferability are described.

The proposed system was presented in front of patients and experienced doctors for their opinions and viewpoints. The authors have conducted questionnaires and interviews (se chapter 5, sections 5.7, 5.8) for the validity of this research. They showed very much interesting with the proposed IDSS based heart monitoring system (Holter Monitor). After the feedback from the medical staff, it is concluded that they have shown much interesting and the proposed system would be the good solution in future to secure the heart patients.

7.3.3. Dependability

According to William M.K. Trochim the viewpoints for traditional quantitative are based on the reliability idea. He also describes that the dependability recognized that the researcher should take care about the variation in research work. It concerns with the ideas that if an observer observes the research work again, then what would be the results, either the same or different. On the other hand, dependability underlines the research needs for context within the research, which is responsible to explain the changes that occur while doing research.

For our research, we distributed questionnaire to the different patients. Most of the patients could understand English but the few of them could not understand it properly. So for those
people we translated it in to Swedish language. There may also be a validity threat because some patients could not understand the logical terms, which were described in the questionnaires. To minimize this type of validity threat, the authors have given a short introductory presentation about the proposed system. The interviews were also conducted in different times schedule because it was not possible to conduct the interviews from medical specialist in the same time and place. Some of them, we have conducted through Skype and telephonic.

7.3.4. Confirm ability

William M.K. Trochim describes that confirm ability refer to qualitative research, to be assumed that every researcher have different viewpoint about the study but the results could be confirmed and substantiated by the others. We have described our research process for this thesis, in chapter Research Methodology and mentioned that we have used case study with the helping of literature review. After getting, some finding a system is proposed and put in front of some selected heart patients and experienced medical staff (see Table 6) for its evaluation and validity.

Interviews were conducted in such a way that one person from the researcher was doing the questionnaire with the medical staff and the other was writing down their opinions. In case of any confusion or misunderstanding, the question was again repeated. From the questionnaire and interviews (section 5.7 and 5.8), we got appreciation, positive feedback, opinion, suggestion and useful information, which confirm the ability of our research work.
8. CONCLUSION AND FUTURE WORK

8.1. Conclusion

In this thesis, we proposed an intelligent decision support system based real-time alarm mechanism, in case of any abnormality in heart, in heart monitoring system. This will improve and enhance the functionality of current heart monitoring system. In the first step, we identified the effectiveness and shortcoming of current heart monitoring system. This was accomplished by conducting systematic literature review, surveys and interviews from heart patients and concerned health professional, from Karlskrona Sweden and Copenhagen Denmark, China and Pakistan. According to the results obtained from the surveys and interviews, there are some deficiencies in the current heart monitoring system. It is also found out, there is no any real time feedback or alarm mechanism, in case of worse condition of the elderly heart patient living alone in home. The current heart monitoring system (holter monitor) only records the ECG for 24-48 hour. It is also necessary for patient to maintaining the patient diary, in current heart monitoring system, which is problem for patient.

In the third step, based on shortcoming in current heart monitoring system, an intelligent decision support system proposed, to solve the issues in current heart monitoring system. The proposed system has capability of real time alert to health professional. The proposed heart monitoring system especially designed for elderly heart patient ling alone in home. The proposed system will also fulfill the future needs of heart monitoring.

In the last step, the proposed heart monitoring system was validated by conducting interviews from concerned health professional and survey from heart patient. We select the interviewees from different countries, Sweden, Denmark, Pakistan and China. This helps us for better validation of our proposed heart monitoring system. The result from interviewees and patients showed, the proposed system is the best option to save the life of elderly heart patients. The proposed system will also help to reduce the hospitalization cost and will be more beneficiary in view of health professional as well as elderly patients.
Q 1. What are the functionalities of the current heart monitoring System for elderly citizens?

RQ1 was answered in the phase of systematic literature review. In this phase, functionalities and effectiveness of current heart monitoring system were identified. During this phase, many functionalities and advantages have been identified. However, precise and most important ones have been described.

Q 2. What are the shortcomings in current holter monitor system?

RQ2 was answered by dividing this question in to two sub phases. In the first phase, shortcoming and issues in current heart monitoring system were identified, which were obtained from literature review. In second phase, the survey was conducted from concerned health professional and heart patients. Through literature review and analysis of survey, we identified shortcoming and issues.

Q 3. What function should be designed for the proposed intelligent support system?

RQ3 was answered by the proposed intelligent decision support system, based on the shortcoming and issues in current heart monitoring.

Q 4. How can proposed Intelligent Support System for heart monitoring be validated?

RQ4 was answered by conducting interviews from concerned health professional and survey-II from heart patient. From the result obtained from analysis of interview and survey, we validate our research work.

Our proposed system has some limitation regarding range and accuracy of ECG data. Noisy environment is not good for our proposed system.

8.2. Future Work

The intelligent decision support system for heart monitoring system described in this thesis is capable of providing real time feedback in case of sensitive condition of elderly heart patient. With the usage of GPS enable mobile, this system can be improved and this becomes effective for patients, away from the home. As the telecommunication infrastructure improves in the future, so the enhancement in the system regarding communication quality
and faster transmission of data, allow the healthcare professionals to provide better patient services.

The battery capacity of the wireless devices (Bluetooth) may limit the duration of recording period, so that a power-saving approach is one innovation that would certainly improve the proposed system efficiency. However, the authors are aware; Holter monitor does not yet support it. Therefore, this approach is remains a valid topic for further investigation. Following development also have space to improve our research work.

- Our future work includes the development of such system for other wearable medical monitoring applications, such as sugar level and blood pressure.
- Our proposed system lays the ground work for further development of a fully functional intelligent decision support systems for heart monitoring
- Special sensors developed for biomedical applications can be used for better result.
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APPENDIX – A, SURVEY-I

Questionnaire: - English Version

Age: 0-45 Years [ ] 46 and Above [ ]
Sex: Male [ ] Female [ ]

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Less than 45</td>
<td>1 (d)</td>
<td></td>
</tr>
<tr>
<td>45 and above</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7: - Respondents in survey I

1. What is your familiar level about current Holter Monitor?

<table>
<thead>
<tr>
<th>Familiar Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely non familiar</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Tends to Non-familiar</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Neither Familiar nor Non-familiar</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Tends to Familiar</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Extremely Familiar</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 8: - Familiar level about Holter Monitor of the respondents
2. At what extent current heart monitoring system fulfill the current requirements for heart monitoring?

<table>
<thead>
<tr>
<th>Degree level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely disagree</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Tends to disagree</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Tends to agree</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 9: - How much Holter Monitor fulfill the current requirements

3. What is your level of satisfaction, while using the Holter Monitor, in case of emergency?

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Not Satisfied</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Tends to dissatisfaction</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Neither Satisfied nor dissatisfied</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Tend to satisfaction</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Strongly Satisfied</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 10: - Satisfaction level while using Holter Monitor
4. How much Holter Monitor can be helpful in severe situation, while a patient could not pass on the message to his doctor or ambulance?

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Helpless</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Helpless</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Neither Helpful nor Helpless</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Helpful</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Strongly Helpful</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 11: - While a patient could not pass on the message to his doctor

5. How much you satisfied with the recording period of ECG?

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Not Satisfied</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Not Satisfied</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Neither Satisfied nor dissatisfied</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Satisfied</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Strongly Satisfied</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 12: - Recording time for ECG
6. How much has heart monitoring system, the level of effectiveness, while evaluating the functionality of implanted devices like pacemaker?

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Dissatisfied</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Neither Satisfied nor dissatisfied</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Satisfied</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Strongly Satisfied</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 13: - Effectiveness, while evaluating the functionality of implanted devices

7. How much you satisfy to maintain patient Diary Sheet, while using the current heart monitoring system?

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Not Satisfied</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Not Satisfied</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Neither Satisfied nor dissatisfied</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Satisfied</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Strongly Satisfied</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 14: - Holter Monitor Diary Sheet
8. Any suggestion to make our proposed IDSS based heart monitoring system more beneficiary for you?

To have ability in real time scenario

Recording period should be extended

Dairy should not be maintained
APPENDIX – B, SURVEY-II

Questionnaire: - English Version

<table>
<thead>
<tr>
<th>Age</th>
<th>Disease Duration</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25 Years [ ]</td>
<td>5-15 Years [ ]</td>
<td>15 &amp; above [ ]</td>
</tr>
<tr>
<td>26-50 Years [ ]</td>
<td>5-15 Years [ ]</td>
<td>15 &amp; above [ ]</td>
</tr>
<tr>
<td>51 and above [ ]</td>
<td>5-15 Years [ ]</td>
<td>15 &amp; above [ ]</td>
</tr>
<tr>
<td><strong>Male [ ]</strong></td>
<td><strong>Female [ ]</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Disease Duration</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25 Years</td>
<td>1-5 Year</td>
<td>4</td>
</tr>
<tr>
<td>26-50 Years</td>
<td>5-15 Year</td>
<td>7</td>
</tr>
<tr>
<td>51 and above</td>
<td>15 &amp; above</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

Table 15: - Total No of patients who have participated in questionnaire

1. How many times you have used the current Holter Monitor?

<table>
<thead>
<tr>
<th>No of Times</th>
<th>Usage of Holter Monitor</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Time</td>
<td></td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Two Time</td>
<td></td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Three Time</td>
<td></td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Four Time</td>
<td></td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Five Time</td>
<td></td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 16: - Patients used Holter Monitor
2. **How much level of familiar to the use of current Holter Monitor?**

<table>
<thead>
<tr>
<th>Level of Familiar</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely not familiar</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tend to not familiar</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Neither familiar nor not familiar</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tend to Familiar</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Extremely Familiar</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 17: - Patients familiar with H. M

3. **What is your level of satisfaction for using the current heart monitoring system?**

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely not satisfied</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Tend to not satisfied</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Neither satisfied nor not satisfied</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Tend to Satisfaction</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Extremely Satisfied</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 18: - Patients satisfaction level
4. What do you think about the efficiency of recording function in the current heart monitoring system?

<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Inefficient</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tend to Inefficient</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neither Efficient nor Inefficient</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Tend to Efficient</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Extremely Efficient</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 19: - Efficiency level of Holter Monitor

5. Do you think that is there any need of alarming system in the current holter monitor, during heart abnormality

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 20: - Alarm in Holter Monitor
6. Do you think that our proposed IDSS based heart monitor, will be the better solution as compared to current system to monitor the hearts disease?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 21 : - Better solution as Holter Monitor

7. Do you think that our proposed heart monitoring system based on IDSS will be the reason for life and time saving?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 22: - Life & time saving with proposed system
8. Do you think that our proposed IDSS based Heart Monitor, will be the better as compared to current system in case of emergency?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Total 20 100

Table 23: - Better solution in case of emergency

9. Do you think that proposed heart monitoring system will reduce your unusual visits to the doctors?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Total 20 100

Table 24: - to reduce unusual visits

10. Any suggestion to make our proposed IDSS based heart monitoring system more beneficiary for you?
Questionnaire: - Swedish Version

➢ Hur många gånger du har använt den aktuella Holter Monitor?
➢ Hur mycket nivå bekant för användningen av nuvarande Holter Monitor?
➢ Vilken är din nivå av tillfredsställelse för att använda det nuvarande systemethjärtat övervakning?
➢ Vad tycker du om effektiviteten av inspelningsfunktionen i det nuvarande hjärtatövervakningssystem?
➢ Tror du att finns det något behov av alarmerande systemet i denna Holterbildskärmen, under hjärtat abnormitet?
➢ Tror du att vår föreslagna IDS er baserade hjärta bildskärm, kommer att varaen bättre lösning jämfört med nuvarande system för att övervaka hjärtan sjukdom?
➢ Tror du att våra föreslagna hjärta övervakningssystem baserat på IDSS erkommer att vara orsaken till livet och tidsbesparande?
➢ Tror du att vår föreslagna IDS: er baserade Heart Monitor, blir bättre jämfört med nuvarande system i nödfall?
➢ Tror du att föreslagna hjärta övervakningssystem kommer att minska dittovanligt besök till läkare?
➢ Eventuella förslag att göra vår föreslagna IDSS er baserade hjärtatövervaknings system flera mottagande för dig?
Questionnaire: - Danish Version

- Hvor mange gange du har brugt den aktuelle Holter-skærm?
- Hvor stor grad af kendte til brugen af nuværende Holter-skærm?
- Hvad er dit niveau af tilfredshed med den aktuelle hjerte overvågningssystem?
- Hvad synes du om effektiviteten i optagelsen funktion i det aktuelle hjerte overvågningssystem?
- Tror du, at er der noget behov for alarmerende system i den aktuelle Holter monitoren, under hjerte abnormitet?
- Tror du, at vores foreslåede IDSS baseret hjerte skærm, vil være den bedste løsning i forhold til nuværende system til at overvåge hjerter sygdom?
- Tror du, at vores foreslåede hjerte overvågningssystem baseret på IDSS vil være årsag til livet og tidsbesparende?
- Tror du, at vores foreslåede IDSS baseret Heart Monitor, vil være bedre i forhold til nuværende system i tilfælde af en nødsituation?
- Tror du, at de foreslåede hjerte overvågningssystem vil reducere dine usædvanligt besøg til lægerne?
- Ethvert forslag om at gøre vores foreslåede IDSS baseret hjerte overvågningssystem mere begunstigede for dig?
APPENDIX – C, INTERVIEW

1. At what extent current holter monitor help you to diagnose the heart disease?

<table>
<thead>
<tr>
<th>Doctors</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Ja, very much</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Helps to diagnose momentary</td>
</tr>
<tr>
<td>Jesper</td>
<td>Of course, it helps</td>
</tr>
<tr>
<td>Adil</td>
<td>It helps for a short time period</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Yes a lot, but for specific time period up to 48 to 72 hours</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>Very much</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>It has very good result for specific time period</td>
</tr>
<tr>
<td>Ea L.</td>
<td>It is good in current scenario</td>
</tr>
</tbody>
</table>

Table 25: - Holter Monitor to diagnose heart disease
2. What is your level of satisfaction by using the current heart monitoring system to diagnose the heart problems for elderly?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>It gives satisfactory result and helps to all heart patients</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Better than ordinary ECG devices</td>
</tr>
<tr>
<td>Jesper</td>
<td>Yes better than previous</td>
</tr>
<tr>
<td>Adil</td>
<td>Can get very pure result</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Using a lot, because it has much capability for recording of heart patients.</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>Yes, very good</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>Much satisfied with its diagnosing ability</td>
</tr>
<tr>
<td>Ea L.</td>
<td>It is good.</td>
</tr>
</tbody>
</table>

Table 26: - Satisfaction level by using the Holter Monitor for elderly
3. At what extent the elderly heart patient are satisfied with the current holter monitor?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Satisfied but not in case of emergency</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Patient has to maintain diary sheet in case of emergency, so elderly are not so much satisfied</td>
</tr>
<tr>
<td>Jesper</td>
<td>Threat may exist because it only records the data but not provide any help.</td>
</tr>
<tr>
<td>Adil</td>
<td>Much</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Ok, but due to maintain the diary, elderly not so much satisfied</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>Very much</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>It can’t provide the real time result so they are not so much satisfied.</td>
</tr>
<tr>
<td>Ea L.</td>
<td>yes</td>
</tr>
</tbody>
</table>

Table 27: - Satisfaction level of elderly heart patient with current holter
4. What do you think that what is the main cause for not satisfaction of elderly heart patients with current heart monitoring system?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Diary sheet, real time helpless, forgotten to write on diary, they have to go to doctor for analyzing.</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Elderly avoid to maintain diary sheet, emergency in case of sleeping</td>
</tr>
<tr>
<td>Jesper</td>
<td>Diary sheet, in case of emergency</td>
</tr>
<tr>
<td>Adil</td>
<td>Unusual visits, in case of emergency when elderly could not call to his doctor</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Helpless in real time scenario</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>In Pak, due to un education elderly could not maintain dairy</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>Not every time but sometimes due to their mode</td>
</tr>
<tr>
<td>Ea L.</td>
<td>When they are alone and have some problem and could not call on</td>
</tr>
</tbody>
</table>

Table 28: - Causes for elderly dissatisfaction with Holter Monitor
5. At what extant do you think that our proposed IDSS based system is implementable in real environment?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Of course good thing for future</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Yes</td>
</tr>
<tr>
<td>Jesper</td>
<td>Everything is possible in the era of advanced technology</td>
</tr>
<tr>
<td>Adil</td>
<td>Might be</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>It can be</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>It will be very good in future to save the lives in real time scenario</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>Yes</td>
</tr>
<tr>
<td>Ea L.</td>
<td>It will take time</td>
</tr>
</tbody>
</table>

Table 29: - Implementation of the proposed system
6. What do you think that how much our IDSS makes it easier for you to know about any abnormality in time about the worse condition of patient as compared with the current system?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Very much</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>Quite easier</td>
</tr>
<tr>
<td>Jesper</td>
<td>Abnormality will be judged in current scenario</td>
</tr>
<tr>
<td>Adil</td>
<td>Improve the result</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Will Enable us, to get more accuracy in case of emergency</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>It will help</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>Yes</td>
</tr>
<tr>
<td>Ea L.</td>
<td>Of course very much</td>
</tr>
</tbody>
</table>

Table 30: - IDSS makes it easier and in time about the worse condition
7. What do you think that, in what level of satisfaction IDSS based Heart Monitoring system will help to avoid from extra ordinary visit of the patients to the doctors?

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjorn E.</td>
<td>Yes, because IDSS based HM will increase the recording capacity</td>
</tr>
<tr>
<td>F. Yousuf</td>
<td>It will help</td>
</tr>
<tr>
<td>Jesper</td>
<td>Of course</td>
</tr>
<tr>
<td>Adil</td>
<td>Yes</td>
</tr>
<tr>
<td>Imtiaz</td>
<td>Will reduce the unnecessary visits</td>
</tr>
<tr>
<td>Nadia M.</td>
<td>It will</td>
</tr>
<tr>
<td>Sidsel L.</td>
<td>Will satisfy</td>
</tr>
<tr>
<td>Ea L.</td>
<td>Will do very much</td>
</tr>
</tbody>
</table>

Table 31: - IDSS based H.M.S. will help to avoid from extra ordinary visit
8. In what extent do you think that the cost for hospitalization can be reduced while using our IDSS based Holter Monitor?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>12.50%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>37.50%</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 32: - Hospitalization cost

9. In what extent the automated system for heart monitoring will improve the result and will make it efficient and rapid than the current heart monitoring system?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>12.50%</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>37.50%</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>12.50%</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>37.50%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 33: - IDSS based system with improving results
10. In what extant do you think that our IDSS based holter monitor will save the lives, time and extra ordinary visits of heart patients to their doctors?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>12,5%</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>50%</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>37,50%</td>
</tr>
</tbody>
</table>

Total: 8, 100%

Table 34: - IDSS based holter monitor as lives and time saver

11. In what extant do you think that our IDSS based Holter Monitor, will be the better solution to monitor the hearts disease in future?

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>12,50%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>12,50%</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>62,50%</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>12,50%</td>
</tr>
</tbody>
</table>

Total: 8, 100%

Table 35: - IDSS based Holter Monitor as a better solution

12. Any suggestion to make our IDSS based heart monitoring system for more efficient, accurate and rapid or any other functionality which we should be include in our system?
APPENDIX – D, CO-RELATE FINDINGS

- Proposed IDSS based heart monitor, will be the better solution

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Patients</th>
<th></th>
<th>Doctors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Respondents</td>
<td>%</td>
<td>Respondents</td>
<td>%</td>
</tr>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>7</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>6</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
<td></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

Table 36: - Co-relation for IDSS base Monitor is better

- IDSS based holter monitor will save the lives, time and extra ordinary visits of heart patients

<table>
<thead>
<tr>
<th>Agree Level</th>
<th>Patients</th>
<th></th>
<th>Doctors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Respondents</td>
<td>%</td>
<td>Respondents</td>
<td>%</td>
</tr>
<tr>
<td>Strongly disagreed</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Tend to disagree</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3</td>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Tend to Agree</td>
<td>4</td>
<td>5</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>Strongly Agreed</td>
<td>5</td>
<td>8</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
<td></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

Table 37: - Co-relation for IDSS base Monitor is live & time saver
APPENDIX – E, PATIENT DIARY SHEET
Figure 24: Holter Monitor Patient dairy sheet
END