Automated Interactive Patient History-Taking System: A Review

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Abstract

The process of history-taking has been challenging for India due to its booming population and severe scarcity of doctors. Inadequate patient history could lead to medication errors, adverse drug reactions and medication non-compliance. Innovations in health information technology (HIT) have great potential for improving the practice of medicine. An automated patient history is collected with the help of a computer. Physicians can use Artificial Intelligence (AI) to help with documentation, analysis of patient data while increasing precision, productivity, and efficacy of the physician. Healthcare providers are looking for regulatory compliant and efficient software for automated patient history taking. In telemedicine, automated history taking before consultation can save physician`s time, have more accurate history which will improve telemedicine experience for the patient especially in times of a pandemic like Coronavirus disease (COVID-19).

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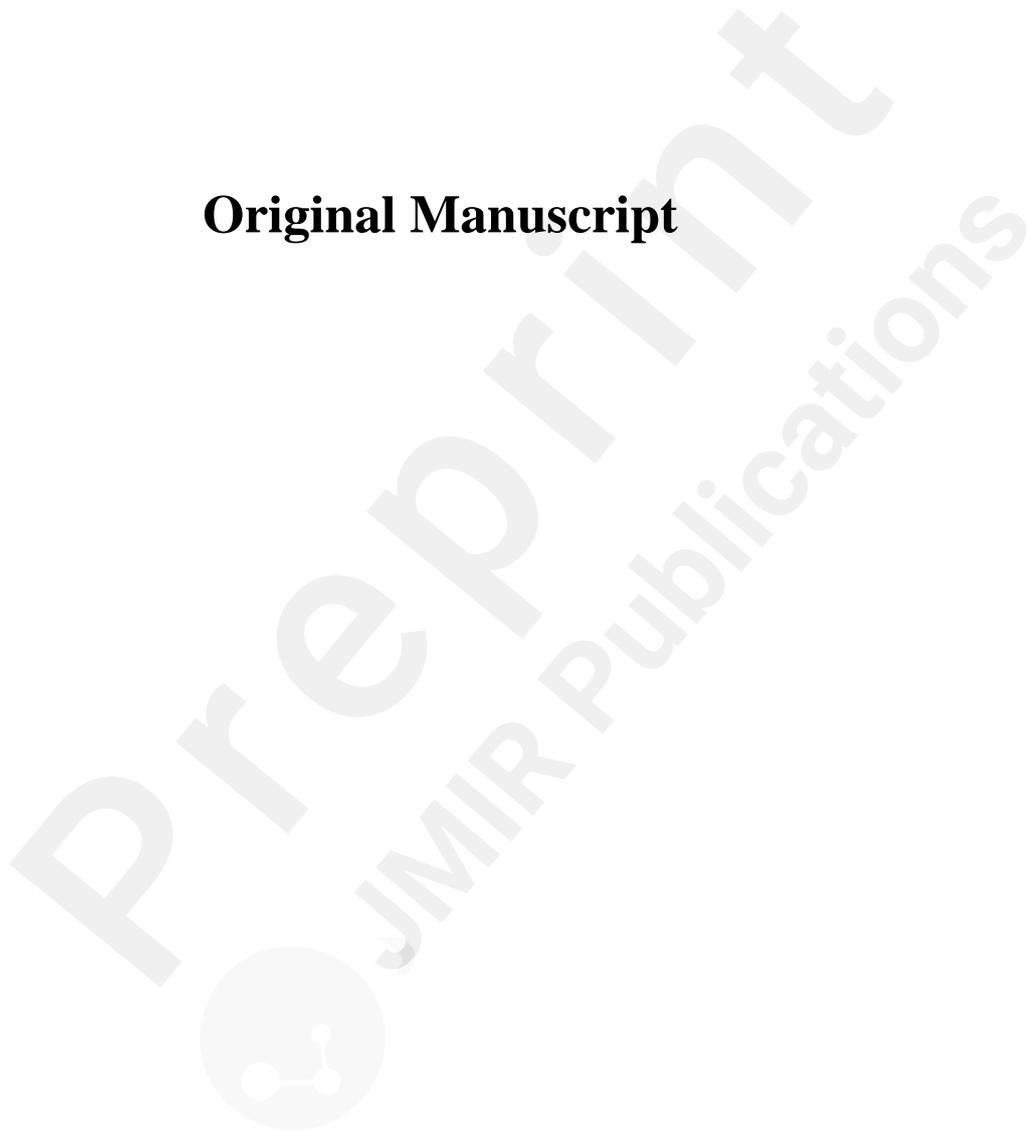
Automated Interactive Patient History-Taking System: A Review

Abstract:

The process of history-taking has been challenging for India due to its booming population and severe scarcity of doctors. Inadequate patient history could lead to medication errors, adverse drug reactions and medication non-compliance. Innovations in health information technology (HIT) have great potential for improving the practice of medicine. An automated patient history is collected with the help of a computer. Physicians can use Artificial Intelligence (AI) to help with documentation, analysis of patient data while increasing precision, productivity, and efficacy of the physician. Healthcare providers are looking for regulatory compliant and efficient software for automated patient history taking. In telemedicine, automated history taking before consultation can save physician`s time, have more accurate history which will improve telemedicine experience for the patient especially in times of a pandemic like Coronavirus disease (COVID-19).

Key words: Patient history, artificial intelligence, telemedicine, automated, digital technology, software

Introduction

A convergence of the science and the art of medicine, the patient history is still the most important tool for making an accurate diagnosis. Regardless of how many new diagnostic tests are available, eliciting information verbally from patients is unsurpassed in diagnostic efficacy. Collecting important information from the patient is essential for effective for making clinical decisions including diagnosis, treatment options, laboratory tests and further therapy plan. An almost accurate patient history can result in correct diagnosis in 70% of the cases. The process of history-taking has

been challenging for India due to its booming population and severe scarcity of doctors. [1] The WHO recommends minimum doctor to patient ratio as 1:1000. However, according to the 2017 edition in Indian Journal of Public Health, India had just 4.8 doctors per 10,000 people. [2] According to the 2015 Global Strategy Report on Human Resources for health, by 2030 resource-limited countries will face a significant imbalance in the healthcare workers to patient ratio. [3] Innovations in health information technology (HIT) have great potential for improving the practice of medicine. In theory, greater and faster information availability could allow physicians more time to thoroughly explain diagnoses and treatments or address patient concerns.

Gathering information that is crucial to guide patient care is known as history-taking. It includes the patient's medical history, social history, allergies, past medication history and current medications. [4] Conventionally, patient history is gathered during consultation where the doctor asks the patient specific questions and then documents the responses in written form or electronic format. Later, a detailed scrutiny of the information gathered is done and a diagnostic conclusion is made. A comprehensive and detailed history of the patient is very crucial to make a diagnosis.

Some of the major factors that hinder appreciable history-taking in developing countries are: overcrowding clinics, inadequate doctor to patient ratio, and low pay scales of healthcare professionals (Figure 1).

As per an observational study, titled 'Four minutes for a patient, twenty seconds for a relative' carried out in the Medical University Centre of Freiburg (Germany), approximately 11.4% of a physician's working time is spent on the communication about diagnosis, therapy and psychosocial issues with the patient. [5] Language barriers can lead to insufficient collection of medical history of the patient. Such communication gaps may lead to unnecessary medical readmission, incorrect diagnosis and treatment plans. [6]

One of the most time-consuming activities of a physician is the taking of a patient's medical history. Many physicians believe that this method of gathering information is not highly effective. This is owed by many reasons. Firstly, a physician's busy schedule does not provide him ample time to explore a patient in-detail. From the patient's point of view, the physician's inability to listen to all his problems may negatively affect the rapport. Secondly, patients vaguely remember their family history, medication history or medical history. Sometimes questions of personal nature could be embarrassing for the patient to answer and he may resort to lying about his history. Such questions can be stressful for the patient and the embarrassment involved could act as a major hindrance towards gathering an effective patient history. [7]

Importance of history-taking:

The patient history directs the physician towards the important elements to be analysed during physical examination. Subsequently, this allows for distinguishing the most relevant problems of the patient from the subsidiary ones. A comprehensive and organised clinical history can help lead to the most accurate clinical decision.

- Past medical history provides a baseline for identification of drug and disease-related problems.
- Social history helps identify if the habits, substance abuse, relationship and hobbies
- Family history helps assort patients who may have a genetic predisposition towards particular diseases.
- Medication history is important in order to prevent the occurrence of any drug-drug interactions.

 All these bits of information put together help in making a diagnostic conclusion.

Evidence demonstrating need of detailed medical history:

A literature search conducted by Thomas Romer, et al. showed that careful history-taking and clinical examination play an important role in the selection of the right contraceptive for women. The reason being some combined hormonal contraceptives are contraindicated in women with real factors like a predisposition to thrombophilia, hypertension, headache, epilepsy, hepatic tumours, diabetes mellitus, nicotine abuse, or age over 35. [8] A case report by Yu Cui and Xiangyan Cui revealed that patient history plays a significant role in the diagnosis of foreign body aspiration in children. The report highlights two paediatric cases that were misdiagnosed due to unclear aspiration history. Later with the help of targeted questions, the authors were able to identify the problem and administer treatment for the same. [9]

A case report by Durga Ghosh and colleagues showed how a case of neuropathy was misdiagnosed as stroke and how a comprehensive focused history helps reveal such an important bit of information. [10] A case report by Jo Fitz and his colleague illustrated the importance of a complete patient history through their case. The case elaborates the incident of a 26 year old man arriving at the ED after a motorcycle accident. The patient was treated for infection and yet signs of infection didn't seem to subside. On suspicions of thyrotoxicosis, his family was interrogated. The enquiry led to the revelation of the patient showing signs of hyperthyroidism before the trauma. The case highlights how a detailed history would have helped make the right diagnosis. [11]

A cross sectional study performed by Sanjay A., et al evaluated the satisfaction of patients who used a self-administered automated medical history-taking device in the emergency department. The study

results proved that patients were highly satisfied with all aspects of the device and felt that it helped them communicate better with the doctor. [12]

Average time taken for history-taking by physicians:

According to Sabin et al, the mean time required by a doctor to take a history and perform physical examination is 20 mins (SD 5 mins). The components in a consultation, which required the greatest amount of time were: documentation (41%), history and physical examination (31%) and communication with relatives (19%). [13] In a study conducted by Wald et al, patient history was collected with the help of a computerised interview. Patients had to take the interview before they met their physicians. On average, a completed interview took 27 minutes. The mean total interview time was 25 minutes for the younger patients and 37 minutes for the older ones. [14]

The impact of inadequate history:

a) Medication errors:

 Lau et al concluded their prospective study by stating that medication history contained in the medical records of the hospital was incomplete as 67% of all the study patients had one or more medications that were either not used but recorded or recorded but not used. [15] According to a study conducted by Frydenberg K. and his colleague among 30 patients that used a total of 250 drugs, 50 medication errors were found that affected 18 of the patients. Twenty seven errors were potentially harmful. These errors were the result of poor collection of patient medication history. [16] A systematic review performed by Tam and his colleagues illustrates with evidence that the incidence of incorrect and inadequate medication history collection at the time of hospital admission is extremely high. They found that up to 54% of patient files had a minimum of one medication history error and approximately 19-75% of them were accidental errors. [17]

b) Adverse drug reactions

According to a survey done by Shenfield et al; out of the 117 patients surveyed, 50 patients had a total of 81 previous adverse reactions; but only 75% were recorded on medication charts and 64% were recorded in the nursing notes. This shows that adverse drug reactions are usually poorly

recorded which can result in patient harm. [18] Negligence while recording other herbal or over the counter (OTC) medications the patient may be taking at admission can lead to disastrous consequences. Constable et al reports the case of a 77 year old woman who was taking St. Johns Wort and Ginseng at the time of admission. These herbal remedies were not recorded on the patient's medication history as a result of which she developed an upper gastrointestinal haemorrhage when she was administered lansoprazole. [19]

c) Medication non-compliance:

Few of the reasons for lack of compliance to medications include: misconceptions or a belief held by patients regarding the treatment, poor patient-physician relationship, poor health literacy, and insufficient knowledge of patients about their disease or treatment. Among few patients that were administered treatment for asthma, the main reason for non-adherence was their belief that the condition wasn't severe enough to be treated daily. [20] In a study that assessed the impact of doctor-patient relationship, participants who felt that their physicians listened to their concerns more were more likely to adhere to their medications. [21]

Available approaches for history-taking:

a) <u>Standard form:</u> The standard form of history-taking involves the physician who gathers relevant information from the patient in a written format during the consultation

b) <u>Electronic medical history:</u> It is very similar to the standard form of history-taking as information is gathered from the patient. Data gathered is entered into the system in an electronic format. Electronic records help reduce the number of medical error occurrences and improve the quality of care. However, some disadvantages of the electronic medical records are change in normal workflow of doctors, loss of productivity, privacy and security concerns. [22]

c) <u>Computer-assisted history-taking system:</u> Digital tools help gather history from the patient prior to consultation, aid in diagnosis and treatment plan.

Integrated Artificial Intelligence (AI) for automated patient history:

An automated patient history is collected with the help of a computer. The patient sits at a computer terminal and answers the questions presented to him by the computer. At the end of the session, a summary of the patient's answers are printed by the computer for the use of the physician. [23] Most history taking systems employ such terminals that display a set of questions that can have only two or more possible answers. The patient's response is fed into the computer by pushing the respective

buttons that indicate their answer. This kind of systems uses the branching technique. [24]. Some of the broad applications of AI in healthcare include: Drug development, disease diagnostics, health monitoring, analysis of health plans, digital consultation, surgical treatments, management of medical data, medical treatment, and personalized treatment. Computers can diagnose a patient using AI via two techniques: flowchart-based approach and database approach. Firstly, in the flowchart-based approach, the computer arrives at a probable diagnosis by combining the various symptoms presented. Secondly, the database approach works by utilizing the principle of deep learning.

Evolution of automated patient history taking:

Scientific literature has been growing ever since Slack et al. (1966) published information on the first online computer history-taking system he had developed at Wisconsin. [25] Since then, other groups have developed computer-linked systems through which patients can report historic information including Barnett and Grossman at the Massachusetts General Hospital, and Mayne at the Mayo Clinic. [23,24] The Automated Medical History System (AMHS) questionnaire designed by Lahey Clinic sends an email to patients prior to their visit. The results of this questionnaire are then used by the clinic to schedule patients to the appropriate specialists. A printed copy of the questionnaire is then used to aid the physician in history taking. [7]

The Automated Patient History Intake Device (APHID) developed by the Portland Veterans Affairs Medical Center (PVAMC) in 2009 to enhance the accuracy and sustainability of ambulatory medication reconciliation is a self-check-in kiosk and reconciliation tool for the ambulatory care setting. The goals of APHID were firstly, to improve the accuracy of the medication history by showing patients digital pictures of their medications on record, and secondly, to integrate APHID into current business processes to promote use and minimize interruptions to workflow. Around 8,170 of a potential 17,275 patients (47%) checked-in using APHID. Patients who used the electronic kiosk were able to complete their medication history as the inclusion of pill pictures improved patient recall. They concluded that consumer-based kiosk offers a feasible model to align the safety and efficiency needs of a health system. [26]

A study was conducted to assess the factors that influence automated patient history systems. Patient age, number of complaints and the time required to complete the instructional portion of the interview showed a positive correlation with overall interview time. There was a negative correlation between the patient's years of formal education and interview duration. The patients who interacted directly with a small online computer (LINC-8) described by Slack et al took an average time of 24.1 min (SD 8.2 min) with a range of 13 to 51 min for the completion of the interview. There was a

positive correlation between age and interview time [r = 0.27. / p < 0.005). There was a negative correlation between education and interview time as expected (r = -0.39, 11 < 0.005). The correlation of number of presenting complaints with interview time was positive (r = 0.47, 1) < 0.025). When criteria such as those discussed here indicate that the patient will perform slowly or at a low level of accuracy, the interview question sequence could be altered. [27]

A self-administered, computer-based questionnaire was tested in another study. 60 mothers completed a mean of 102 questions in a mean time of 35 minutes. The computer consistently detected more abnormal symptoms than were recorded in the physician's history; on rechecking these were found to be valid. This proved that computer-based history taking will prove to be a very powerful aid in gathering, storing and retrieving paediatric clinical information. [25]

Patient Touch™ is an innovative, hand-held touch-screen tablet developed by Humantouch Inc. A study was conducted among ambulatory emergency department (ED) patients. The objective was to allow ambulatory ED patients to use the device to self-administer a clinical history (detailed chief complaint history, comprehensive past medical history, medication history and review of symptoms) and determine patient perceptions of the physical characteristics of the device, time required to complete the session, appropriateness and detail of the questions, potential impact and overall satisfaction. Out of 173 participants that used Patient Touch™, 93.6% of them felt the physical product was easy to use; 97.1% felt the questions could help describe their condition; 97.8% felt using Patient Touch™ would help them organize their thoughts and communicate better with their physician, 94.8% thought it would increase the quality of healthcare, and 97.1% (94.6– 99.6%) would like to use the product again in the future. The study was conducted at a largely Hispanic county ED, and involved only patients with 1 of 6 pre-determined chief complaints. A control group was not included. The results of this pilot study revealed that patients were highly satisfied with all aspects of the Patient Touch™ self-administered, hand-held, touch-screen tablet. Importantly, subjects felt it would help them better communicate with their doctor, would improve their overall quality of care and overwhelmingly increased their desire to use it in the future. [28]

Automated medical history–taking devices (AMHTDs) are novel history taking methods that provide physicians with complete history of the patient with an added advantage of differential diagnosis. A study was conducted to assess the effectiveness of an AMHTD in obtaining accurate differential diagnoses in an outpatient service. A pilot study involving 59 patients presenting to the emergency outpatient department and suffering from various conditions affecting the limbs, the back, and the

chest wall were included. Physicians were randomized into 2 groups, one used the AMHTD and one didn't use the device. For each patient, physicians were asked to make a comprehensive differential diagnosis based on the history and clinical examination. In the intervention group, physicians read the AMHTD report before laying out the final diagnosis. In both the groups, a senior physician had to give a differential diagnosis that was the gold standard. The results showed that the differential diagnosis accuracy was higher in the intervention group (AMHTD) than in the control. The novel AMHTD was able to determine 73% of correct differential diagnoses. Patients were satisfied and considered that they were able to accurately describe their symptoms. It was evident that the AMHTD helped physicians in making accurate differential diagnoses, particularly in complex cases. This could be explained not only by the ability of the AMHTD to make the right diagnoses, but also by the exhaustive anamnesis provided. [29]

Computer Assisted Instruction (CAl) programs are being extensively used in history-taking programs. A pilot study was carried out that studied the feasibility of using the computer as a screening device in child psychiatry. Mothers were asked to answer questions regarding their child's behaviour. The procedure was generally acceptable to the mothers, and the data proved useful in distinguishing normal controls from a patient group. The authors conclude that this is indeed a feasible use of the computer. [30]

CLEOS® is an automated history taking tool that merges laboratory data; analyzes the clinical significance of the data collected; sends reports to physicians for findings, diagnoses, prevention, follow-up; gives recommendations for diagnosis and treatment. A study was conducted in dyslipidemic patients where patients answered questions regarding themselves using the CLEOS® program. The program collected data of present illness, past medical history, current medications, social history, and family history. A total of 213 medical records and CLEOS® interviews for the same set of 213 unselected patients were compared to evaluate performance of these tasks by physicians and the CLEOS® program. Patients (n = 81) at high risk for a coronary event were identified on the basis of history by CLEOS®. A computerized history-taking program together with automated analysis of clinical data collected by self-interview of patients can outperform routine medical care for categorising risk for coronary events, for identifying treatment targets, identifying patients with risk of hypercholesterolemia, and for identifying past and present statin-induced adverse drug effects. [31]

Arintra is the first assistive AI solution in India for comprehensive history taking and machine

learned provisional diagnosis generation. It is a novel AI based diagnosis decision-support system that assists doctors and medical assistants capture a patient's comprehensive and chronological history and in generating a provisional diagnosis. The different tasks performed by AI in Arintra are clinical history-taking, clinical natural language processing and medical diagnostics. The tool saves five minutes of doctor's time per patient. Data is securely encrypted and made anonymized at the source. The tool is able to provide a patient history before the consultation even begins. This tool flags drug-drug interactions, automatically generates preliminary draft of discharge summary and improves patient retention. Currently, there are 20 pilots running in major corporate and private hospitals, SHCOs and independent clinics in Andhra Pradesh, Telangana and Kerala.

Future Outlook:

In the coming years, patients will seek more telemedicine services as coronavirus disease (COVID-19) has already uplifted its usage and acceptance worldwide. Rapidly changing regulations for healthcare IT in India could be challenging in deploying such technology in the healthcare set-up. The solution lies within the advent of National Digital Health Blueprint. The trend of digitizing patient records in India is growing amid demand for standardization of operations in medical care. Healthcare providers are looking for regulatory compliant and efficient software.

In telemedicine, as patient clinical information is collected before consultation, doctors need not worry about missing important patient information and can consequently communicate effectively with them. This technology enables focused and personalized interaction with the patient lending more time for counselling too.

Conclusion:

With the help of AI-enable computerised-interactive history-taking applications, patient history taking becomes a seamless and hassle-free process. The vision is to provide good quality healthcare in India and other developing countries. It is essential to focus on improved efficiency and accuracy of the patient-doctor information that helps reduce medical errors and improve patient safety.

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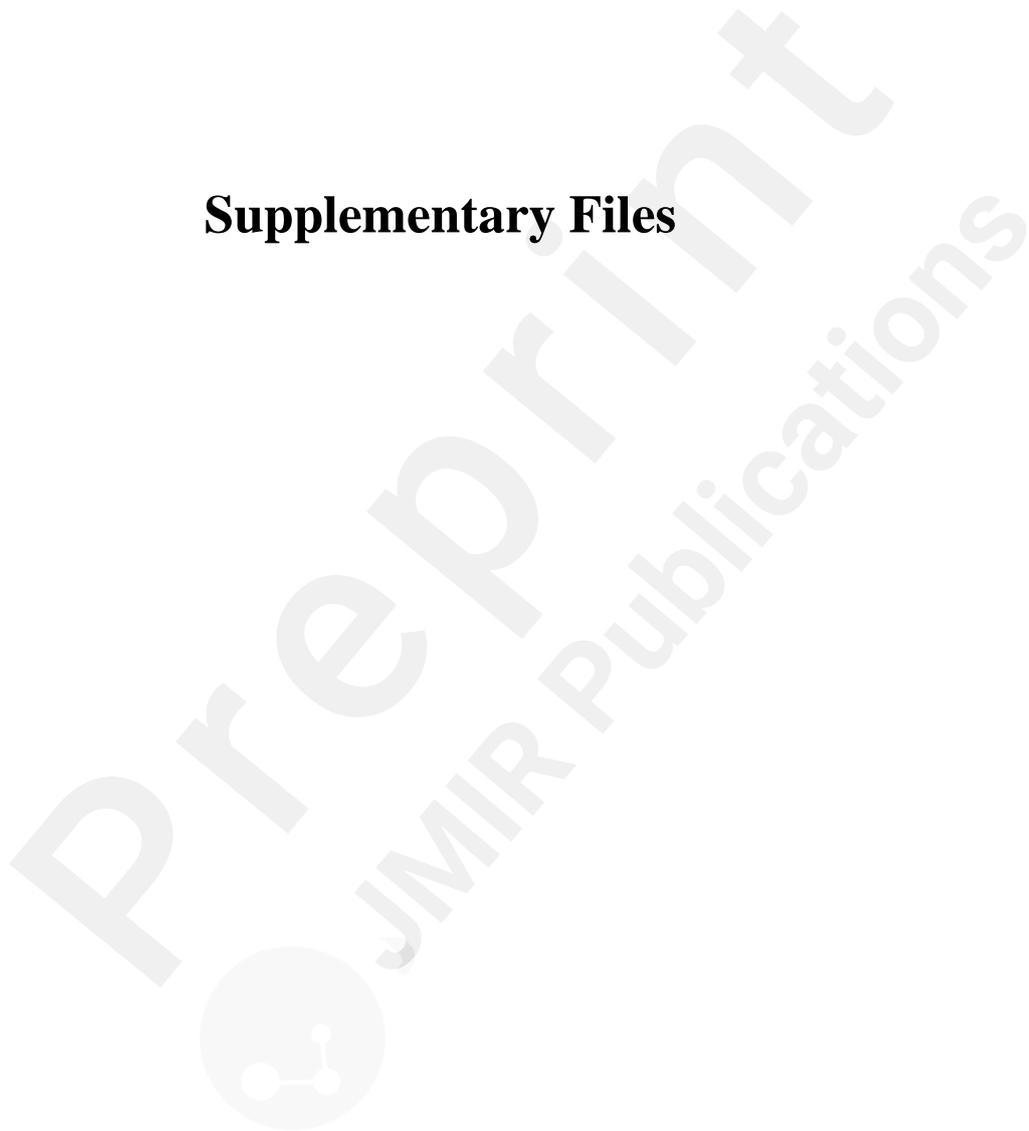
Images

Figure   1:   Challenges   in   history-taking
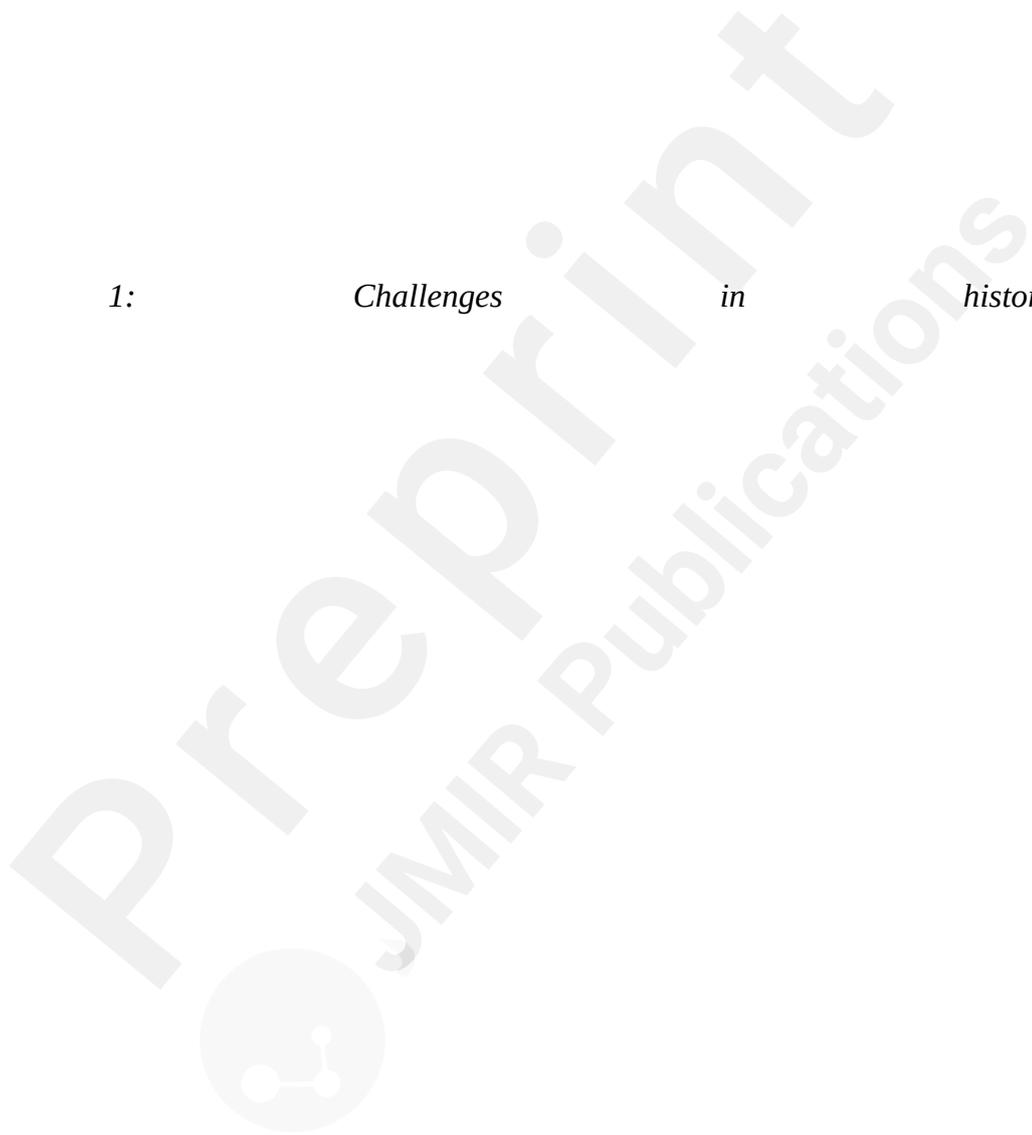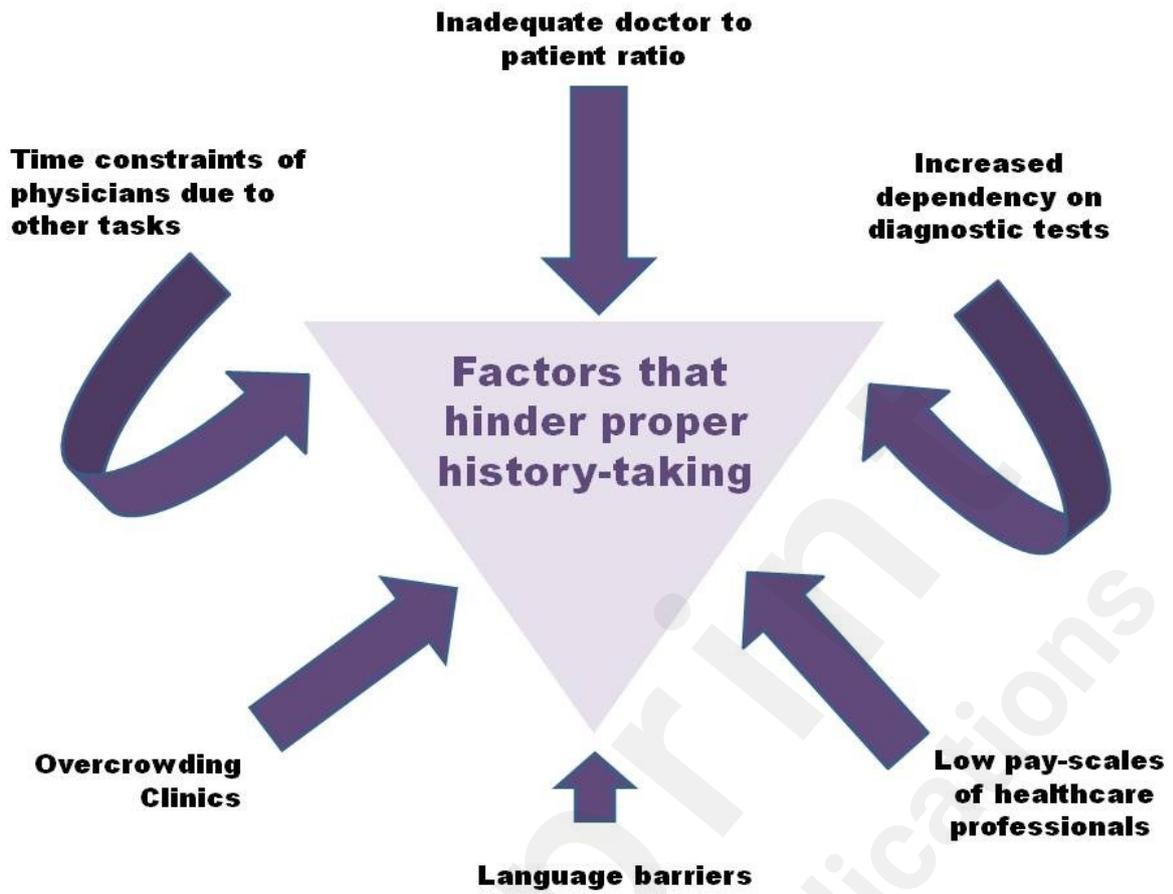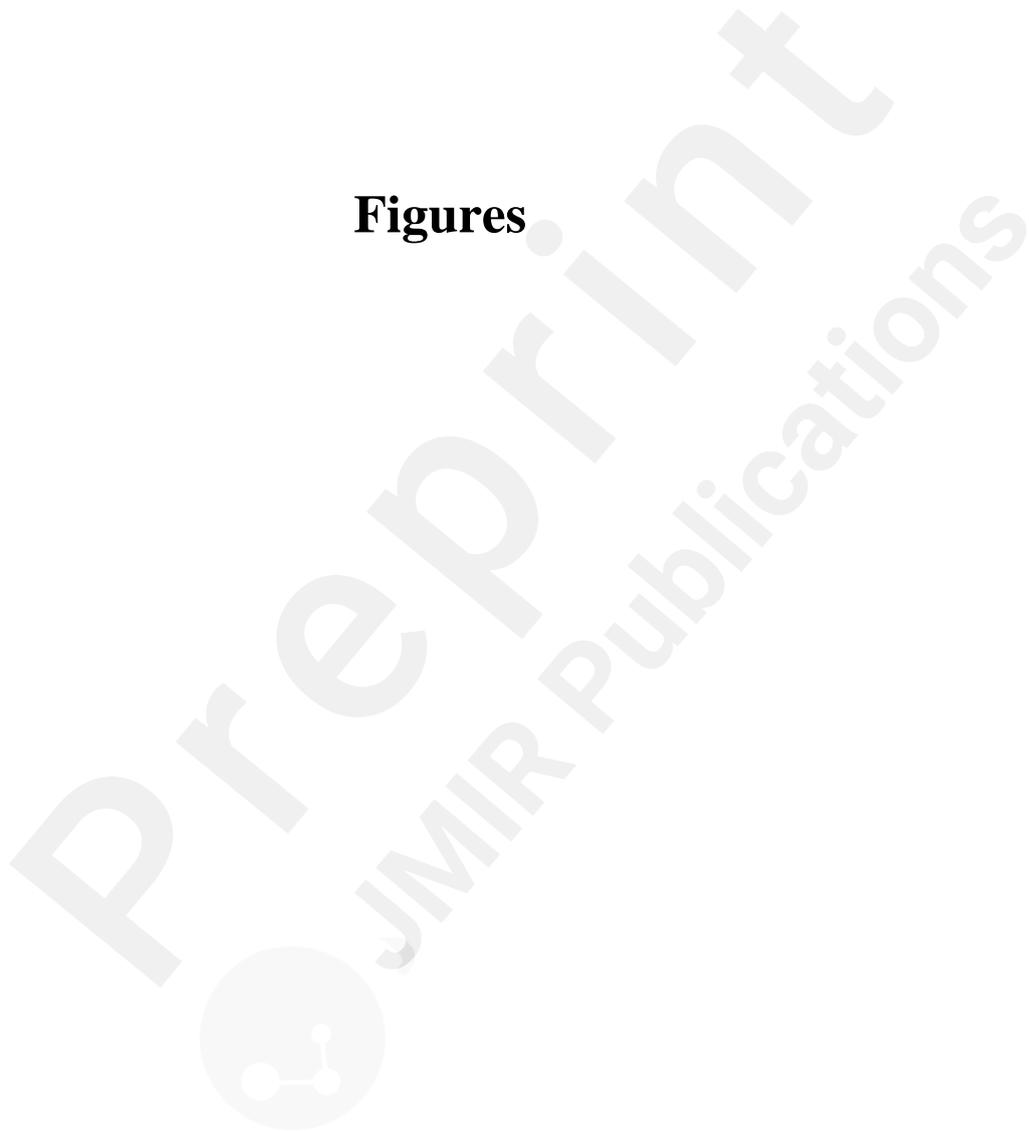
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Figures

Challenges in history-taking.