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मसौदा भारतीय मानक

इंटरनेट ऑफ थिंग्स (आईओटी) - तनाव प्रबंधन, अच्छे स्वास्थ्य और खुशहाली के लिए आईओटी

Draft Indian Standard

Internet of Things (IoT) – IoT for Stress Management, Good Health and Well-Being

ICS: 35.240.95

LITD 27- Internet of Things & Digital Twin Sectional Committee	Last date for comments: 12 February 2025

FOREWORD

[formal clauses will be added later]

This draft Indian Standard will be adopted by the Bureau of Indian Standards, after the draft finalized by the Internet of Things and & Digital Twin Sectional Committee, will be approved by the Electronics and Information Technology Division Council**.**

CONTENTS

INTRODUCTION

The history of mankind has recently seen the result of a deadly pandemic. The time-tested reality proved that a substantial chunk of the untimely fatalities took place as a result of the invisible stress that impacted many of the people who were otherwise fit and healthy. The pandemic has not only acted as an eye opener but also served as an opportunity to have academic logistics to deal with situations like this. There is a genuine need to have an international standard, which is capable of addressing stress management using IoT with an end to end perspective.

Stress was first defined by in 1936 by Hans Selye, a pioneering endocrinologist from Hungary (Rochette and Vergely, 2017), as: “the non-specific response of the body to any demand.” (Fink, 2009).

Stress is a normal reaction of the body to any change. The body reacts to the change in various ways that could be physical, psychological, or emotional. These changes are collectively defined as stress and for the purpose of this document when we refer to stress, we are referring to these changes only, irrespective of the trigger for the change.
The World Health Organization (WHO) defines stress as "the reaction people may have when presented with demands and pressures that are not matched to their knowledge and abilities and which challenge their ability to cope."

Hence it is clear that stress is not a disease and does not have any pathological disease markers, but it is definitely a condition. Mild to moderate stress for a limited periods of time are considered positive stress. This helps us focus on task at hand, for example a surgeon performing a surgery would need to be alert and have full concentration on the procedure. But continuous stress without relief or relaxation is referred to as negative stress or chronic stress.

The Yerkes-Dodson law is a model of the relationship between stress and task performance. It proposes that you reach your peak level of performance with an intermediate level of stress, or arousal. Too little or too much arousal results in poorer performance. This is also known as the inverted-U model of arousal. The chart in figure 1 indicates relationship between stress and performance as per existing study.

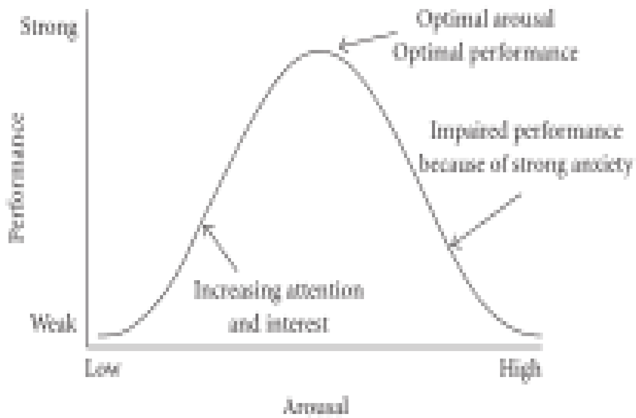


Figure 1: Reference Relationship between stress and performance as per Yerkes-Dodson law[15]

Chronic Stress has impact on the body, on the mood and the behaviour. It needs to be managed and hence requires measurement devices to aid proper management. Stress is a global phenomenon and unfortunately, an inseparable adjunct of human health. Since stress is such an important leading and primary indicator of good health, it needs to be given the importance it warrants by making a reference standard around its measurement and management using commercially available off-the-shelf IoT devices and systems.

As on date, there has been no standard which fulfils this very purpose comprehensively. It is not just a visualisation of an academic or literary approach by the word Stress or Health or Well-being, rather intending to have a holistic approach. The focus should be on the value which this standard would add towards Human health which is also explicable by UN Sustainable Development Goal No. 3 i.e., Good health and Well-being.
IoT being a cross-cutting technology in nature is utilized towards the functional data flow through interfaces and between entities. The IoT ecosystem ensures stress management, health, fitness and well-being of an individual through data analytics, integrating personal health records with due consideration to privacy and confidentiality.

The intention of this standard is to highlight the use of IoT devices and analytics as powerful tools for stress management and well-being. Through the data collected from IoT devices, it is possible to gain valuable insights into an individual's physical, mental and emotional state. This information can be further used to develop personalized stress management plans. Overall, it will enable an IoT ecosystem for management of stress level, monitoring of health parameters and ensuring fitness and well-being of an individual.

The aim is to provide a non-binding reference standard that will be used:
1. By the people to understand and make efforts to manage chronic stress holistically

2. By the solution providers to take into consideration the end to end view of stress management for the individual

3. To ensure that individual data becomes part of repository like POR so that the history and longitudinal view is available if and when the individual encounters the healthcare ecosystem

It is limited to well-being space only. Once stress manifests into secondary disease conditions, it becomes part of the corresponding clinical pathway of the Healthcare ecosystem which is not addressed by the scope of this standard.

1. SCOPE

This document specifies the utilization of IoT ecosystem for management of stress levels, health, fitness and well-being of an individual. This document provides

a) For an overview of stress and its management

b) For framework and interfaces among different entities in the IoT ecosystem

c) To elaborate and define the functional data flow for stress management

d) To integrate the personal health records of the individual while ensuring privacy and confidentiality of the individual

e) For monitoring of health parameters using IoT technology & wellness devices

f) Use of data analytics for stress management

The scope does not include the clinical domain and medical therapeutics prescribed or required for cure of any disease or ill-health of the individual.

2. NORMATIVE REFERENCES

ISO No	***Title***
ISO/IEC 30141	IoT Reference Architecture
ISO/TR 20055:2018	Health informatics — Person-owned document repository for PHR applications and health information exchange
ISO 18308:2011	Health informatics — Requirements for an electronic health record architecture
ISO/IEC 27400: 2022	Cyber security — IoT security and privacy — Guidelines
ISO 25237: 2017	Health informatics — Pseudonymization
ISO/IEC 27001	Information security, cybersecurity and privacy protection — Information security management systems — Requirements
ISO/IEC 27002:2022	Information security, cyber security and privacy protection — Information security controls

ISO 31000:2018	Risk management — Guidelines
ISO 27799: 2016	Health Informatics-Information Security
ISO/TS 82304-2:2021	Health software Part 2: Health and wellness apps — Quality and reliability
ISO/IEEE 11073	Health informatics — Device interoperability

3. TERMS AND DEFINITIONS

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

a. IEC Electropedia: available at https://www.electropedia.org/
b. ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Personal Owned Repository (POR)

A PoR is a repository of health-related information about an individual which is owned, managed, accessed and shared by the individual using computer technology. A PoR can be implemented in many different ways such as on a mobile device, USB, personal computer, or by using a PHR application or server-based cloud service. **[Source: ISO/TR 20055:2018(E)]**

3.2 Electronic Health Record (EHR)

Information relevant to the wellness, health and healthcare of an individual, in computer-processable form and represented according to a standardized information model **[SOURCE: ISO 18308:2011, 3.20]**

3.3 IoT user

In this context, IoT User is any user willing to monitor, control and eliminate stress

3.4 IoT service providers

Any individual or agency providing services including but not limited to prognosis, diagnosis, and analytics

3.5 IoT developers

Any individual or agency responsible for development, management and implementation of system

3.6 Heart Rate Variability (HRV)

Statistical results calculated from consecutive RR intervals **[SOURCE: ISO 4135:2022(en), 3.11.5.9]**

3.7 Blood Pressure (BP)

Pressure in the large arteries of the body, typically measured in the bracheal artery **[SOURCE: ISO 16976-6:2023(en), 3.3]**

3.8 Breathing Rate (BR)/ Respiratory rate (RR)

Number of breaths per minute **[SOURCE: ISO 13138:2012(en), 3.10, ISO 16976-6:2023(en), 3.16]**

4. ABBREVIATED TERMS

IoT Internet of Things

HRV Heart Rate Variability

BP Blood Pressure

BR Breathing Rate

RR Respiratory rate

EDA Electrodermal Activity

GSR Galvanic Skin Response

WHR Waist to Hip Ratio

TC Total Cholesterol

HDL High density lipoprotein

EEG Electroencephalograph

PSS Perceived Stress Scale

STAI State-Trait Anxiety Inventory

PoR Personal Owned Repository

DHEA-S dehydroepiandrosterone-sulphate

SBP Systolic Blood Pressure

DBP Diastolic Blood Pressure

HDL high-density lipoprotein

LDL Low-density lipoprotein

HCP Healthcare Personnel

AI Artificial Intelligence

ML Machine Learning

5. IOT ENABLED STRESS MEASUREMENT REFERENCE FRAMEWORK

Stress may be defined as a real or interpreted threat to the physiological or psychological integrity of an individual that results in physiological and/or behavioural responses. Refer to Annex D for pathology related to Stress.

Stress involves a stressor and a stress response. A stressor may be a physical insult, such as trauma or injury, or physical exertion, particularly when the body is being forced to operate beyond its capacity. Other physical stressors include noise, overcrowding, excessive heat or cold. Stressors also include primarily psychological experiences such as time-pressured tasks, interpersonal conflicts, unexpected events, frustration, isolation, and traumatic life events, and all these types of stressors may produce behavioural responses and evoke physiological consequences such as increased blood pressure, elevated heart rate, increased cortisol levels, impaired cognitive function, and altered metabolism. IoT ecosystem can be utilized to measure these consequences to indicate levels of stress and correspondingly help in managing them towards good health and well-being.

5.1 Stress Measurement: Parameters

In literature and studies, there are number of biomarkers suggested that could potentially measure stress levels and suggestive clinical pathways. As per existing research, 10 biomarkers were included in preliminary validation - 12-h urinary cortisol, epinephrine, and norepinephrine output; serum dehydroepiandrosterone-sulphate (DHEA-S), total cholesterol (TC) to high density lipoprotein-(HDL) cholesterol, and LDL-cholesterol/HDL-cholesterol; plasma glycosylated haemoglobin (HbA1c); aggregate systolic and diastolic blood pressure (SBP and DBP); and waist-to-hip (W/H) ratio (Seeman et al., 1997a). Apart from this Heart Rate Variability is also shown to be strongly correlated with Stress.

The below table enlists number of parameters associated with stress. A more detailed description of these can be found in Annex A.

Table 2: Details of parameters associated with stress
(Clause 5.1)

Parameter	Brief Description	Linkage to Stress

Heart Rate Variability (HRV)	A measure of the variation in time between each heartbeat	High HRV indicates lower stress. Lower HRV indicates less resilience and correspondingly higher stress
Cortisol level	Level of Cortisol in Sweat, Saliva, Urine	Elevated levels for prolonged time (6 or more months) indicates chronic stress
Blood pressure (BP)	The pressure of circulating blood against the walls of blood vessels.	Higher stress has indirect linkage to BP
Breathing Rate (BR) / Respiratory rate (RR)	The rate at which breathing occurs and is measured in breaths per minute	Higher BR/RR can be an indicator of stress
Skin Conductance / Electrodermal activity (EDA) / Galvanic Skin Response (GSR)	Measure of continuous variation in the electrical characteristics of the skin	Higher stress leads to arousal of sweat glands leading to higher skin conductance
Waist to Hip Ratio (WHR)	The dimensionless ratio of the circumference of the waist to that of the hips. This is calculated as waist measurement divided by hip measurement	Higher levels can be indicators of chronic stress
Adrenaline, Noradrenaline, DHEA-S,	Hormones and neurotransmitters produced by adrenal glands that boosts heart rate, blood pressure, and energy as body’s response to stressful situations	Higher levels indicate higher stress levels
Total Cholesterol (TC) to High density lipoprotein (HDL)	Ratio of Combined (HDL + LDL) cholesterol to HDL	Higher levels can be indicators of chronic stress
Glycosylated Hemoglobin (HbA1c)	Test to measure the quantity of sugar in the blood over the past 2-3 months	Higher levels can have indirect linkage to stress

Electroencephalograph (EEG)	Electrical activity of the brain	EEG signals can be translated to indicate stress levels
Stress Assessment Questionnaires Perceived Stress Scale (PSS). State-Trait Anxiety Inventory (STAI). Holmes and Rahe Stress Scale.	Number of Self-assessment questionnaires that assess the degree to which individuals perceive their lives as stressful based on current experiences and past events	Provided in 9) of Annex A of the document.

Many of the above biomarkers are based on blood/serum tests and invasive in nature. Invasive tests must be performed by qualified professionals with sterilized equipment and should not be performed by individuals themselves. With the current technology available in the commoditized space today, following are some of parameters that are measurable by IoT devices/sensors:

a. Heart Rate Variability (HRV)
b. Breathing rate (BR) / Respiratory rate (RR)
c. Sweat/Saliva Cortisol levels
d. Skin conductance / Electro dermal activity (EDA) / Galvanic Skin Response (GSR)
e. Systolic and Diastolic Blood pressure (BP)
f. Wait-to-hip ratio (WHR)
g. Electroencephalograph (EEG)
h. Stress Assessment questionnaires available through web/mobile apps to record stress levels

5.2 Stress Measurement: Functional Data Flow

The functional data flow of the proposed IoT based system is given in Figure 2. Number of parameters are measured by wearable sensors, IoT devices and the data is rendered through corresponding mobile apps for the user to view via communication protocols like Bluetooth, NFC, Wi-Fi, etc. The data is stored securely onto the cloud via Internet and accessed via the corresponding native mobile/web apps.

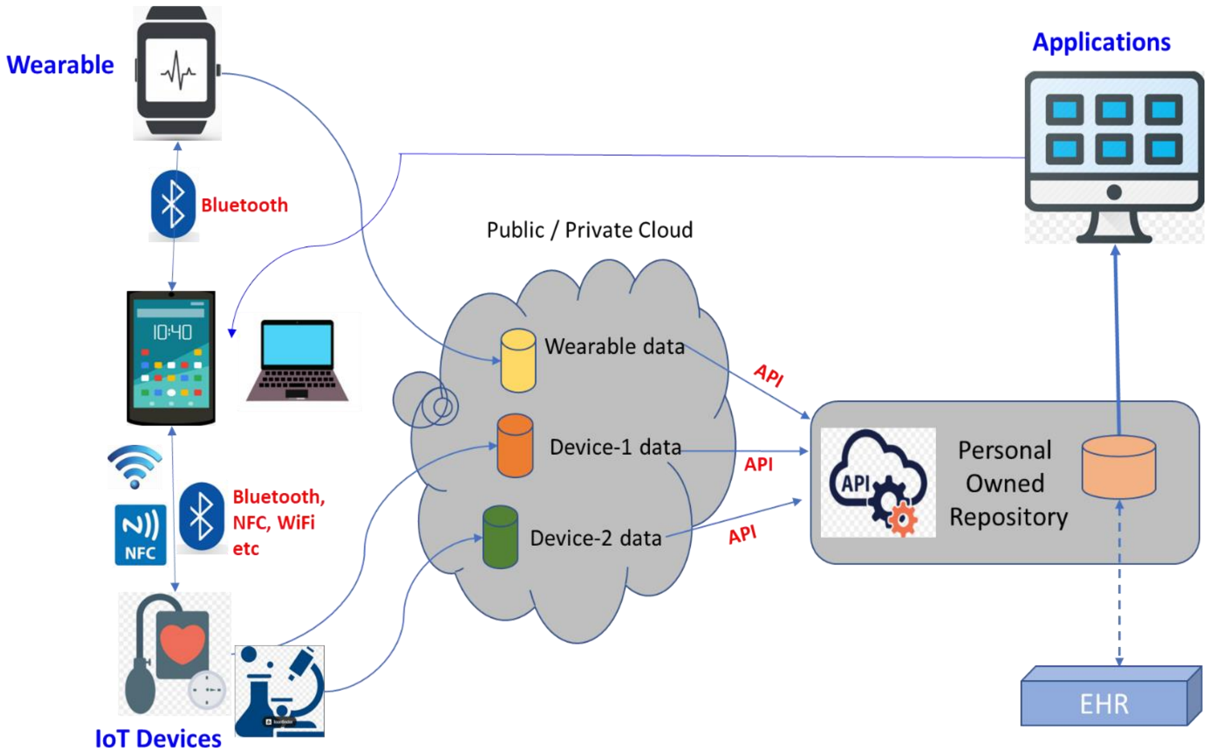


Figure 2: Functional data flow for the IoT based system

The data from the various devices can be collected via APIs into a Personal Owned Repository (POR). As defined in ISO/TR 20055:2018(E) the basic purpose of POR is to enable a person to collect and share their health information. Potential sources of information include clinical information from healthcare providers, results from laboratories, health status data such as vital signs from personal sensor devices, and any health-related information entered by the individual who owns the POR. Once collected, the information stored in the POR will be available for sharing with other parties as determined by the individual that owns the POR. Also, the data in POR can be correlated and consumed by various stress management applications. The applications may comply to ISO/IEC TS 82304-2.

The overall framework and interfaces among different entities in the IoT ecosystem will be as per ISO/IEEE 11073 Personal Health Devices.

A typical Stress Management System is depicted in the block diagram (See Figure 3). The acquired data from various IoT devices is stored in the POR as per standard HL7 data and information model (ISO/TR 20055:2018). Online and/or Offline Analytics modules can process the data and alert the user when the values are beyond the limits. Number of AI/ML models integrated in the applications can process the data to predict trends and suggest the user to monitor/control the leading parameters affecting stress.

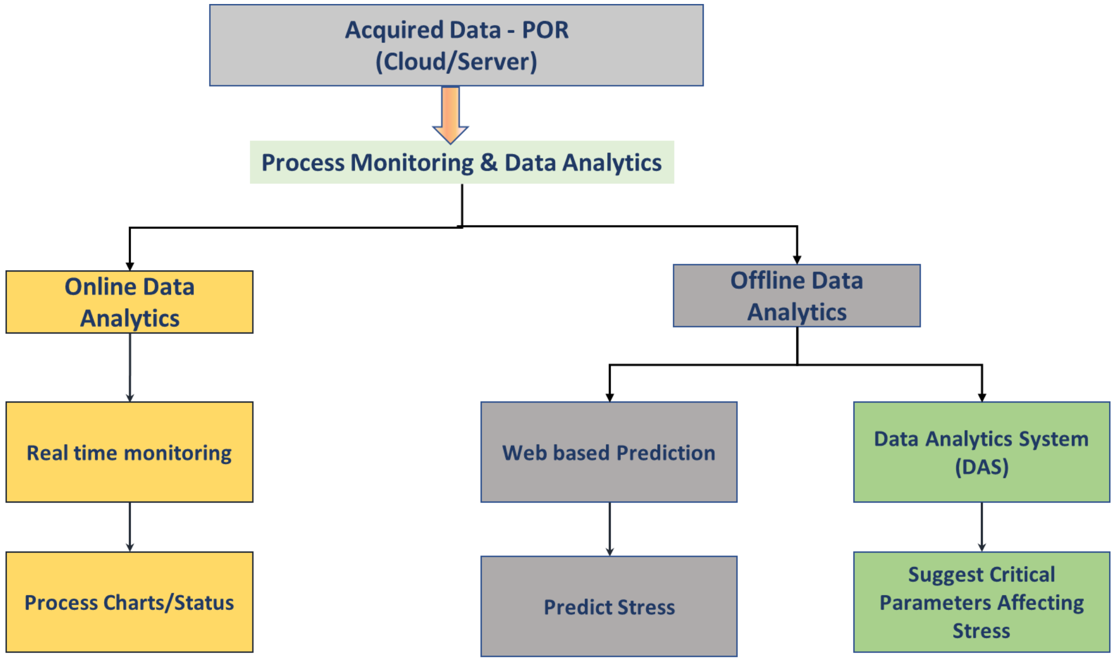


Figure 3: Utilization of acquired data in the IoT enabled Stress Management System

6. IOT ENABLED STRESS MANAGEMENT: WORKFLOW

The IoT devices and the workflow associated with the data collection & analytics is a fundamental building block of the Stress Management ecosystem. Through the data collected from IoT devices, it is possible to gain valuable insights into an individual's physical, mental, and emotional state by application of data analytics. This information can be used to develop personalized stress management plans that address the root causes of stress and improve overall well-being.

The flow chart depicts the typical workflow for an individual in a Stress Management system. IoT is the pivotal aspect of this workflow although there are aspects of data transfer and background processing that are not directly IOT related. However, describing them in this standard is essential to illustrate the end-end workflow of stress management.

Step	Description
1	Identify and measure Stress related parameters through the wearable IoT devices e.g. HRV, BP.
2	Monitor the parameter using IoT devices for a period of time to get a baseline e.g. 30 days average with ±2 Std deviations

3	Continue periodic monitoring if the observed values are within limits using IoT devices
4	When observed values are outside limits, monitor other co-related parameters using IoT devices to verify the stress condition
5	If required, use Stress assessment questionnaire to validate the stress condition This step is not directly related to IoT but is part of the overall end-end workflow
6	Create Personal Stress Management plan to demote the stress levels e.g. Meditation, Holistic healing etc This step is not directly related to IoT but is part of the overall end-end workflow
7	Monitor the original identified parameter using IoT devices to check for improvement.
8	In case of Improvement, continue to periodically monitor the parameters using IoT devices.
9	In situation of no improvement, modify the improvement plan to check if the situation improves This step is not directly related to IoT but is part of the overall end-end workflow
10	Visit an HCP if the situation remains unchanged and/or deteriorates. Adhere to care plan recommended by HCP till complete recovery (This part of workflow is clinical and not in scope of this standard)

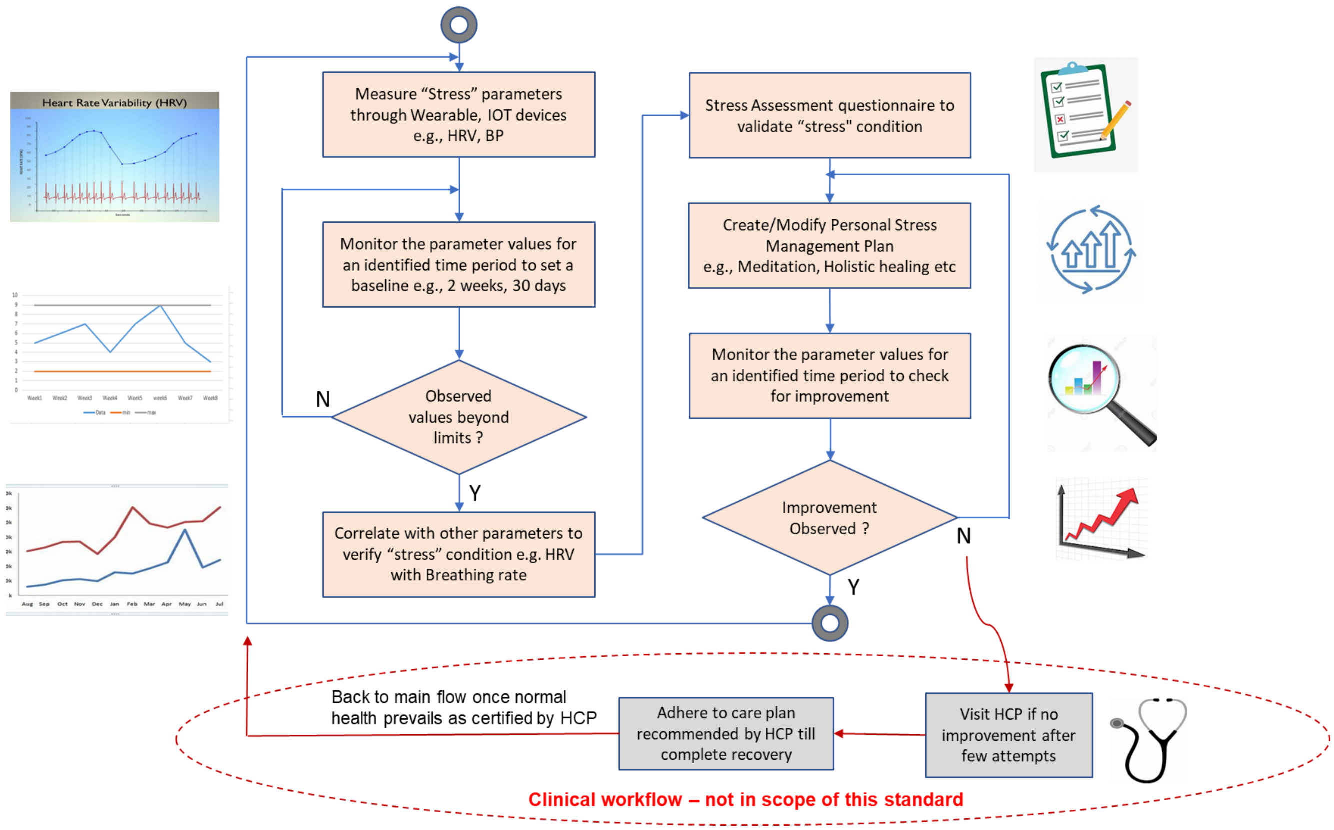


Figure 4: Stress Management Workflow

This workflow can be encapsulated in various Mobile/desktop applications provided by the wearables, IoT device manufacturers and other Wellness app providers.

7. SECURITY OF THE IOT ENABLED STRESS MANAGEMENT SYSTEM

7.1 General

Stakeholders of IoT systems are defined in ISO/IEC 30141 & ISO/IEC 27400:2022. Dependencies among stakeholders of IoT system are defined as IoT ecosystem, and further include relationship between IoT products and services; implementation of security measures and consequences involved in case of failure in security measures. IoT ecosystem can also be expanded in case of any adverse effects on implemented IoT (e.g. in case of cyber-attacks on single system or entire system), and risk associated with adverse effects shall also be addressed by adopting extended requirements to the information security management systems requirements as per ISO/IEC 27001, ISO/IEC 27002 and ISO 31000:2018

7.2 Security Controls

Security for IoT stress measurement system is very important. Security measures shall not be limited to IoT user but also extended to IoT service providers and IoT developers. Security measures shall be applicable to the IoT ecosystem as well as IoT expanded ecosystem (during the time of adverse effects on implemented IoT system). Relevant controls should be imposed as per ISO/IEC 27400:2022. Few of the relevant controls are discussed in this document though these do not restrict stakeholders to deploy other required controls to maintain high level of security.

Controls related to Policy for IoT security, Organization of IoT security, Asset management, Security in connecting varied IoT devices, Verification of IoT devices and systems design, monitoring and logging, protection of logs, User of suitable networks, User and device authentication, provision of software and firmware updates, and sharing vulnerability information are applicable for IoT service providers or IoT developers in ISO/IEC 27400:2022.

Controls related to Equipment and assets which are located outside of physical secured areas, Secure disposal or re-use of equipment, Secure IoT system engineering principles, Secure development environment and procedures, and management of vulnerable devices are specifically applicable for IoT service providers in ISO/IEC 27400:2022.

Controls related to secure disclosure of information regarding security of IoT devices is specifically applicable for IoT developer in ISO/IEC 27400:2022.

Controls related to contacts and support services, Initial setting of IoT device and service, deactivation of unused devices, and secure disposal or re-use of IoT devices are specifically applicable for IoT user in ISO/IEC 27400:2022.

It is essential to adopt pseudo anonymity system especially for performing prognosis, diagnosis as well as analytics as per ISO 25237: 2017.

The security and privacy of the data collected will be ensured as per ISO 27799: 2016 Health Informatics-Information Security.

8. PRIVACY AND REGULATORY CONSIDERATIONS FOR THE IOT ENABLED STRESS MANAGEMENT SYSTEM

Data collected from IoT devices helps gain valuable insights of an individual’s physical, mental, and emotional state via application of data analytics. It is utmost important for the IoT Stress Measurement Devices to comply to currently available International Standards, Data Privacy Laws & Regulations that would help to guide a risk based approach/design, to securely operate to mitigate the potential risk of data misuse etc., since the data is widely shared over internet, with downstream third parties, cloud sites, government agencies, insurance companies, law enforcement, data aggregators, data banks, social media sites etc. Once data leaves the device, the device user has basically lost all control over how that data will be used and shared. Knowing that this information can be used to develop personalized stress management plans to improve overall well-being, there is always potential risk if individual’s identity & personal data gets into wrong hands like a fraudster leading to misuse and hijacking the identity causing further damages to individual’s life during data storage, transfer/transmission to remote server etc.

The design of Stress Management system shall take into considerations about effective implementation of privacy assurance framework around data protection, privacy, and Individual's identity. They shall have security or privacy controls built in to protect sensitive data.

The IoT User can update permissions, view their data access history, and delete their data. It confirms the user identity and consent, limits accidental data collection from other sources such as individuals in the vicinity, and monitors vital parameters of the user. The collected data must be considered HSD (highly sensitive data) or PHI (protected health information) and must not be used outside the system. The data and system must be protected from unauthorized access. It seeks the user's consent to use their data, takes the measured vital parameters of the patient, and uses AI or any similar technology for diagnosis of any health issues and communicates the same. All the parameters measured by the IoT device (sensors) are fed into this system or sent out from the system, anonymized and/or encrypted which thereby, uses AI or any similar technology for diagnosis of health problems. It is desirable for the user to have the ability to temporarily or permanently shut down the system.

The system shall comply with applicable privacy laws and regulations prevailing in the region/country from time to time. For example, HIPAA, GDPR, Digital Personal Data Protection Rules & Regulations, EU AI Act, EU MDR, etc.

Annex A
(Informative)

STRESS RELATED PARAMETERS

This section describes in detail the various parameters that can be indicators of stress

A.1 Heart Rate Variability (HRV)

HRV is simply a measure of the variation in time between each heartbeat. This variation is controlled by a primitive part of the nervous system called the autonomic nervous system (ANS). It works behind the scenes, automatically regulating our heart rate, blood pressure, breathing, and digestion among other key tasks. The ANS is subdivided into two large components: the sympathetic and the parasympathetic nervous system, also known as the fight-or-flight mechanism and the relaxation response.

The brain is constantly processing information in a region called the hypothalamus. The ANS provides signals to the hypothalamus, which then instructs the rest of the body either to stimulate or to relax different functions. It responds not only to a poor night of sleep, or that sour interaction with your boss, but also to the exciting news that you got engaged, or to that delicious healthy meal you had for lunch. Our body handles all kinds of stimuli and life goes on. However, if we have persistent instigators such as stress, poor sleep, unhealthy diet, dysfunctional relationships, isolation or solitude, and lack of exercise, this balance may be disrupted, and your fight-or-flight response can shift into overdrive[3].

Heart rate variability: How it might indicate well-being - Harvard Health

Your body has many systems and features that let it adapt to where you are and what you're doing. Your heart's variability reflects how adaptable your body can be. If your heart rate is highly variable, this is usually evidence that your body can adapt to many kinds of changes. People with high heart rate variability are usually less stressed and happier. In general, low heart rate variability is considered a sign of current or future health problems because it shows your body is less resilient and struggles to handle changing situations. It's also more common in people who have higher resting heart rates. That's because when your heart is beating faster, there's less time between beats, reducing the opportunity for variability. This is often the case with conditions like diabetes, high blood pressure, asthma, anxiety and depression[4,5].

Heart Rate Variability (HRV): What It Is and How You Can Track It (clevelandclinic.org)
The Link Between Heart Rate Variability (HRV) and Stress - Sports Medicine Weekly

A.2 Cortisol levels

Cortisol is a hormone produced by the adrenal glands that helps regulate several important functions in your body. One of the most prominent functions is regulating how your body responds to stress. When you experience stress, your adrenal glands release cortisol into your body which temporarily increases your blood sugar levels to provide the body with a boost of energy (adrenaline, a hormone commonly associated with the "fight-or-flight" response, is also released by the adrenal glands in times of stress). This process helps you perform better in stressful situations that have a relatively short duration (acute stress), such as when you are in danger or striving to hit a tight deadline at work. However, if you experience stress over a long-term, sustained length of time—otherwise known as chronic stress—the body's stress response makes negative health outcomes more likely. That's largely because chronic stress can cause consistently elevated cortisol levels, and this can alter bodily processes and functions in harmful ways.

In situations involving short-term or acute stressors, cortisol levels typically remain elevated for several hours following a stressful event. If cortisol levels remain elevated for a prolonged amount of time (such as 6 or more months), this is a good indicator that someone is experiencing chronic—or long-term—stress[6].

Cortisol levels and stress: how cortisol levels and stress are connected - Blog | Everlywell: Home Health Testing Made Easy

A.3 Blood pressure (BP)

The body releases a surge of hormones when under stress. These hormones cause the heart to beat faster and the blood vessels to narrow. These actions increase blood pressure for a time. There's no proof that stress by itself causes long-term high blood pressure. But reacting to stress in unhealthy ways can raise blood pressure and increase the risk of heart attack and stroke. Heart disease also might be linked to certain health conditions related to stress, such as Anxiety, Depression etc. There's no proof that these conditions are directly linked to high blood pressure. But the hormones the body makes when under emotional stress might damage arteries. The artery damage might lead to heart disease. And symptoms of depression and anxiety might cause some people to forget to take medicines to control high blood pressure or other heart conditions.

Stress can cause a steep rise in blood pressure. But when stress goes away, blood pressure returns to what it was before the stress. However, short spikes in blood pressure can cause heart attacks or strokes and may also damage blood vessels, the heart and the kidneys over time. The damage is like the damage from long-term high blood pressure. Stress-reducing activities can help lower blood pressure. Although people with high stress and high blood pressure would generally see blood pressure go down after controlling stress, reducing stress might not lower blood pressure in everyone[7].

Stress and high blood pressure: What's the connection? - Mayo Clinic

Anxiety and stress themselves don't necessarily elevate blood pressure in the long term, " says preventive cardiologist Luke Laffin, MD, "but they often have an impact on lifestyle factors, which can absolutely contribute to elevations in blood pressure". While both categories of stress (acute and chronic) can cause BP to go up, they have different long-term effects. Acute stress is temporary stress caused by a specific event, like work deadline, argument with spouse etc. Bouts of anxiety, like having a panic attack, can also cause acute stress that raises your blood pressure. If we're in a stressful situation, the normal physiologic response is to increase blood pressure," Dr. Laffin explains. "Acute stress can increase your heart rate and rev up your sympathetic nervous system, which, in turn, raises your blood pressure". In these cases, your symptoms dissipate once your stressor is gone. You complete your deadline, you make up with your spouse, you catch your dog, you come down from your panic attack — and soon, your blood pressure returns to normal too. It is normal to experience changes in blood pressure throughout the day, and your body is typically skilled at managing them. "The body can handle acute changes in blood pressure pretty well," Dr. Laffin says. "What we're really worried about is chronically elevated blood pressure". Researchers don't know as much about the ways chronic stress affects blood pressure, Dr. Laffin notes. But what they do know is that stress can impact your lifestyle habits and increase your risk of health concerns. "Stress can manifest as unhealthy lifestyle habits that can ultimately impact your cardiovascular risk," Dr. Laffin explains. When you're chronically stressed, you may sleep less, not exercise, make unhealth dietary choices, smoke/drink etc. All these habits can lead to higher blood pressure and increase your risk of stroke or other heart issues[8].

Stress and Blood Pressure: Are They Connected? – Cleveland Clinic

A.4 Waist-to-hip (WHR) ratio

Recent studies have shown an association between uncontrollable stress and abdominal fat distribution. It has been suggested that changes in cortisol secretion might represent one possible mechanism for this relationship. This study investigated whether body fat distribution, determined by WHR, is related to salivary cortisol levels in response to laboratory stressors. The findings support the hypothesis that cortisol secretion might represent a mechanism for the observed association between stress and abdominal fat distribution. Furthermore, differences in coping and appraisal may suggest that a particular psychological pattern might influence the reactivity of the adrenal-cortical system to stress, and subsequent fat distribution.

A.5 Adrenaline level (epinephrine) and Noradrenaline level (norepinephrine)

Adrenaline and Noradrenaline are the hormones and a neurotransmitters that boosts your heart rate, blood pressure, and energy in stressful situations. They are produced by the adrenal glands and plays a vital role in the body's acute stress response by stimulating the sympathetic nervous system.

A.6 Serum dehydroepiandrosterone-sulphate (DHEA-S) level[10]

Dehydroepiandrosterone (DHEA) is a hormone produced by both men and women. It's released by the adrenal glands. The symptoms of DHEA deficiency can include - prolonged fatigue, poor concentration, a diminished sense of well-being. One of the most common causes of high DHEA is constant and persistent daily stress.[11]

A.7 Total cholesterol (TC) to high density lipoprotein- (HDL) cholesterol, and HDL-cholesterol[12]

Total cholesterol represents the combined amount of "bad" cholesterol (low-density, or LDL) and "good" cholesterol (high-density lipoprotein, or HDL) in your blood. The measurement is then compared to your individual HDL result to gauge your risk for heart disease and stroke. There are number of medically reviewed material that indicate a strong relation of stress to cholestretol[13].

Studies have shown that stress increases cholesterol not only in the short-term but can also affect cholesterol levels even years down the road. Those who manage stress in unhealthy ways (via hostility, social isolation, or self-blame, for example) tend to have lower levels of HDL (good) cholesterol. Stress is known to increase cholesterol levels and in particular the bad LDL cholesterol. The amount of stress in your life isn't as important as how you deal with it. The more anger and hostility that stress produces in you, the higher (and worse) your LDL and triglyceride levels tend to be. Stress encourages the body to produce more energy in the form of metabolic fuels, which cause the liver to produce and secrete more of the bad cholesterol, LDL. Also, stress may interfere with the body's ability to clear lipids. One theory is that stress hormones' function is to provide fuel for a potential fight-or-flight situation. But if this energy is not used, it gradually accumulates as fat tissue. In addition, sugars that are produced with stress are repeatedly left unused and are eventually converted into triglycerides or other fatty acids.

A.8 Plasma glycosylated hemoglobin (HbA1c)[14]

A glycosylated Hemoglobin (HbA1c) is a lab test to measure how much sugar has been in your blood over the past 2-3 months. It is used to detect prediabetes, diagnose diabetes as a part of health checkups, and monitor treatment efficacy. If you're experiencing stress or feeling threatened, your body reacts in the fight-or-flight response. During this response, your body releases adrenaline and cortisol into your bloodstream, and your respiratory rates increase. This can increase blood glucose levels if the body cannot adequately process it.

A.9 Stress Assessment Questionnaires

Apart from physiological parameters described above, there are number of self-assessment questionnaires that can be administered to gauge individual stress levels based on personal situations, life events etc. There are many such instruments, below are one of the popular ones:

- Perceived Stress Scale (PSS): This is a widely used tool that assesses the degree to which individuals perceive their lives as stressful. It contains 10 questions that measure the frequency and intensity of stress-related feelings.

  https://www.cmu.edu/dietrich/psychology/stress-immunity-disease-lab/scales/pdf/brazil.pdf

- State-Trait Anxiety Inventory (STAI): This tool is used to assess anxiety in individuals. It consists of two separate subscales that measure state anxiety (how anxious an individual is feeling at the moment) and trait anxiety (how anxious an individual generally is)

- General Health Questionnaire (GHQ): This tool measures the psychological well-being of individuals. It consists of 28 questions that assess an individual's ability to perform normal activities, their mood, and their overall sense of well-being

- Job Content Questionnaire (JCQ): This tool is used to measure work-related stress. It assesses factors such as job demands, job control, and social support at work

- Burnout Measure (BM): This tool assesses the degree of burnout in individuals. It consists of questions that measure emotional exhaustion, depersonalization, and personal accomplishment

- Holmes and Rahe Stress Scale: This tool assesses the amount of stress an individual is experiencing based on life events that have occurred in the past year. It assigns point values to different life events, and the total score indicates the level of stress the individual is experiencing.

- Patient Health Questionnaire (PHQ-9): The PHQ-9 is used in mental health contexts to evaluate depression. It serves multiple purposes: conducting initial screenings to identify possible cases, diagnosing depression using its scoring system, and tracking symptom severity over time. This enables healthcare professionals to monitor a patient's treatment response and make necessary adjustments.

  https://med.stanford.edu/fastlab/research/imapp/msrs/_jcr_content/main/accordion/accordion_content3/download_256324296/file.res/PHQ9%20id%20date%2008.03.pdf

- The GAD-7 is a short questionnaire designed to evaluate anxiety disorders, especially generalized anxiety disorder (GAD). It inquires about the frequency of common anxiety symptoms experienced over the past two weeks. Scores are based on how often these symptoms occur, with higher scores suggesting a higher likelihood and severity of GAD. Although useful, it is not meant for self-diagnosis. If you suspect you have GAD, consulting a mental health professional is crucial for accurate assessment and treatment.

  https://adaa.org/sites/default/files/GAD-7_Anxiety-updated_0.pdf

- HADS - Hospital Anxiety and Depression Scale: The HADS is a 14-question tool used to screen for anxiety and depression in various settings. It has two parts: 7 questions for anxiety and 7 for depression. Each question is scored based on how often you experience the feeling (0-3 points). Higher scores indicate a greater chance and severity of anxiety or depression (normal: 0-7, mild: 8-10, moderate: 11-14, severe: 15-21).

  The HADS is quick, easy to use, and focuses on mental symptoms rather than physical ones, making it useful in medical settings. However, it's not a replacement for a full diagnosis by a mental health professional. It's a first step to identify people who might need further evaluation and treatment for anxiety or depression.

  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2276214/

Annex B
(Informative)

DATA ANALYTICS

With the advancement of IoT technology, the use of sensors, wearables, and mobile apps have enabled the collection of vast amounts of data related to an individual's physical, mental, and emotional state. This section describes the use of data analytics with the data collected from IoT devices to manage and improve stress and well-being. Through data analytics, the data from the IoT ecosystem can be analyzed to draw inferences and conclusions about stress levels and overall well-being. This can help individuals and care providers to understand the status quo, optimize their state of being, or make more feasible guided decisions. The algorithms can analyze the data over time and make it usable not just for individuals but also for larger demographics.

B.1 Approach

Different approaches to analytics can be effectively used in the domain of IoT for stress management and well-being. Descriptive analytics is for looking at the collected data and inferring what has happened, diagnostic analytics for why such manifestation had happened, predictive analytics for what is going to happen to the user based on the collected data and patterns, and prescriptive analytics for what care should be provided as a next step.

B.2 Descriptive Analytics

In the context of stress management and well-being, descriptive analytics can be used to understand the patterns and trends of an individual's physical and mental state, helping to manage stress and improve overall well-being. For instance, wearable devices can track an individual's heart rate, sleep patterns, and physical activity over time.

B.3 Diagnostic Analytics

Diagnostic analytics involves the analysis of data to identify the cause of a particular event or trend. Diagnostic analytics can be used to identify the factors that contribute to stress and other negative health outcomes. For instance, by analyzing the data collected from wearable devices, it is possible to identify the triggers that cause stress, such as lack of sleep or physical inactivity. This information can be used to develop personalized stress management plans that address the root causes of stress.

B.4 Predictive Analytics

Predictive analytics involves the use of statistical models and machine learning algorithms to predict future events and trends. Predictive analytics can be used to predict the likelihood of an individual experiencing stress or other negative health outcomes. For instance, by analyzing the data collected from wearable devices, it is possible to predict an individual's stress levels based on their physical activity, heart rate, and other factors. This information can be used to proactively manage stress and prevent negative health outcomes.

B.5 Prescriptive Analytics

Prescriptive analytics involves the use of data, statistical models, and machine learning algorithms to make recommendations on how to optimize a particular outcome. Prescriptive analytics can be used to develop personalized stress management plans that are tailored to an individual's specific needs. For instance, by analyzing the data collected from wearable devices, it is possible to identify the most effective stress management techniques for an individual based on their physical and mental state.

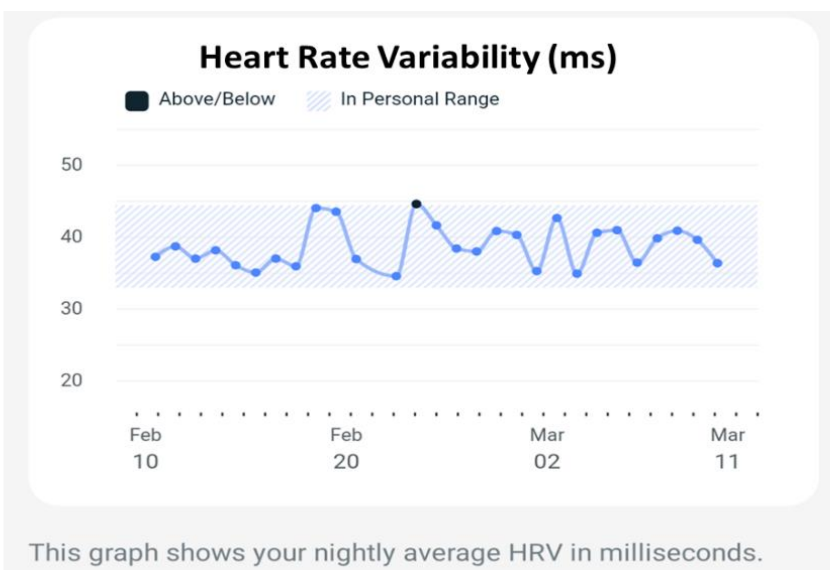
Annex C
(Informative)

USE CASE EXAMPLE

The below example describes a typical use case of how IoT devices/sensors can help an individual to monitor self for stress levels and take proactive actions to ensure good health and well-being.

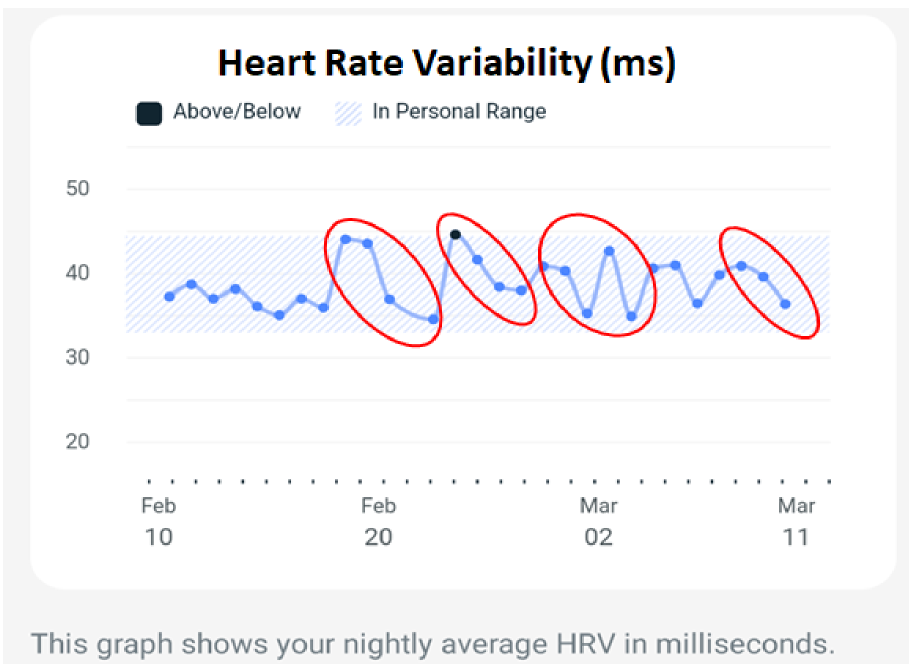
Ms. A is a young healthy individual, conscious about her well-being and maintains a healthy lifestyle. She exercises regularly and does periodic health checkups. She is aware that chronic stress although not a disease, can have detrimental effect on the health leading to secondary conditions and disease. As a health-conscious lady, she has a wearable that monitors her daily exercise, breathing rates, sleep patterns and stress related parameters such as Heart rate variability (HRV). The wearable has a mobile app that displays the daily values and the weekly/monthly periodic trends of these parameters. The data is stored securely on the wearable cloud and rendered through the wearable web-app as well.

For e.g. the below chart displays the nightly averaged HRV in milliseconds from Fitbit-Sense wearable device for A. The HRV varies from person to person depending on age, gender, sleep, lifestyle, personal circumstances etc. The wearable computes the baseline based on few days of data i.e. 30 days in this case of Fitbit and determines personal range as +- 2 standard deviations from the baseline. A deviation outside the personal range may be potential alert for the individual to consider one’s stress situation.



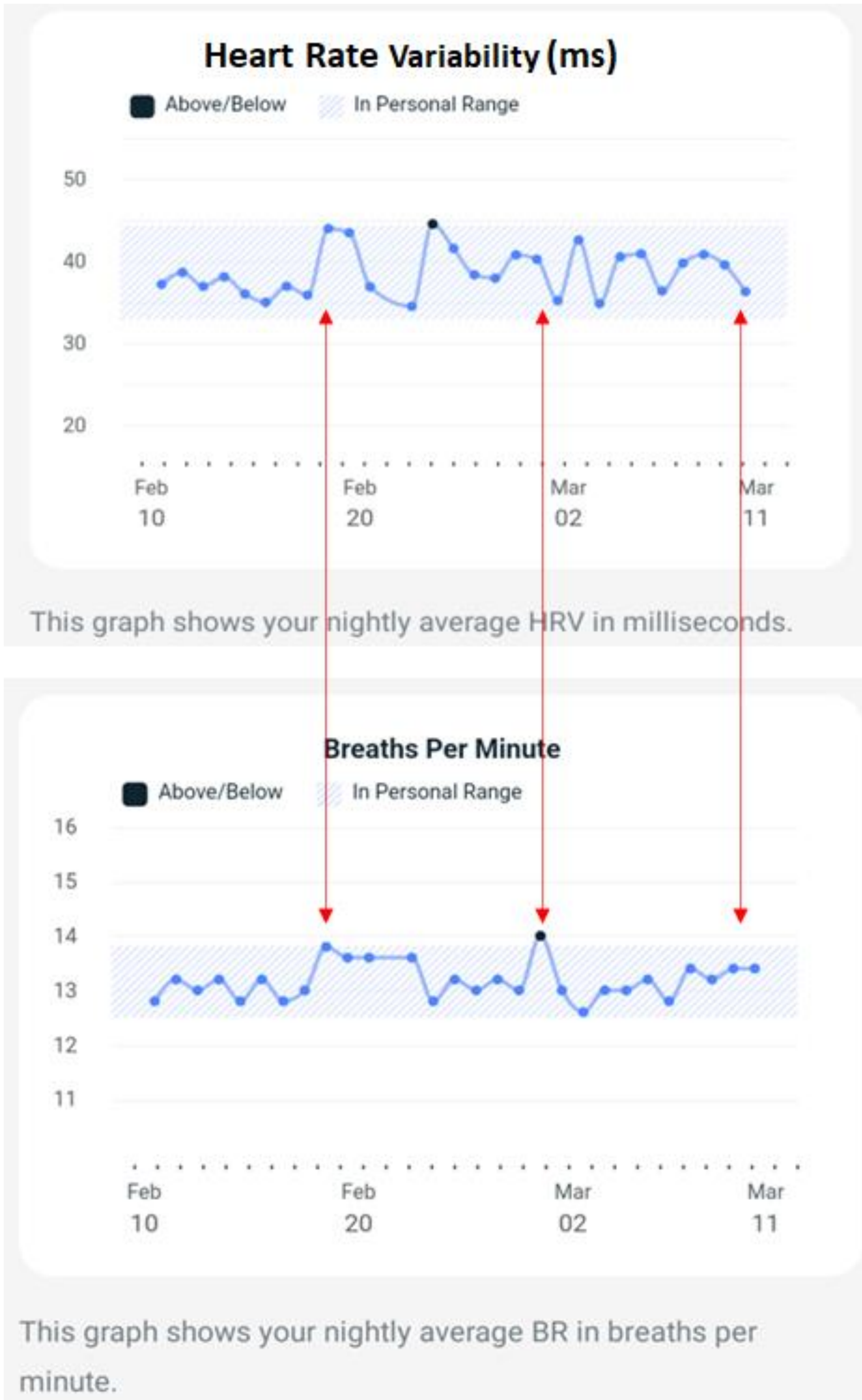
As described in section-9, descriptive analytics such as above can help A understand the patterns of various parameters over time and aid in understanding physical and mental state of herself.

Continuing the example further, as indicated in section-5, A knows that people with high heart rate variability are usually less stressed and happier. In general, low heart rate variability is considered a sign of current or future health problems because it shows your body is less resilient and struggles to handle changing situations. However, absolute HRV number is not of much significance, but the trend offers much more insights on an individual's well-being from stress perspective. Referring to below chart the outlined parts can be reflected on by A on the personal situations leading to the stress. "A recounts that current reorganizations are leading to stressful situations for her and reflected so in the HRV patterns below."



A point value of a single parameter is not sufficient to confirm the stress condition and determine course of action. There may be a momentary situation for an individual or an erroneous value causing false alarm. Descriptive analytics showing the pattern of the various parameters on a temporal axis used in conjunction with other parameters can indicate the underlying chronic stress condition thus enabling the individual to determine next course of action.

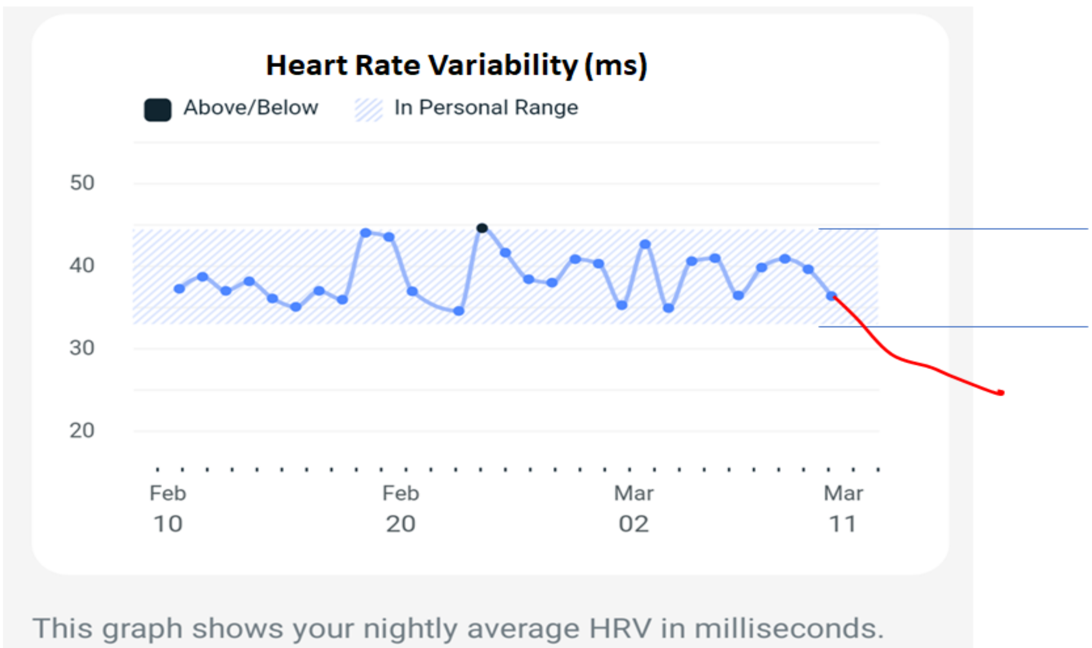
For e.g., referring to figure below, lower HRV trend may indicate stress, but it could be a point value or an erroneous measurement " Although A is aware of her personal situation in office could be causing stress, and HRV already indicates so, she can validate that by referring another parameter such as Breathing rate in conjunction with HRV. Individually by herself and certain other applications could correlate these values and alert A on her underlying stress situation.” This is an example of diagnostic analytics.



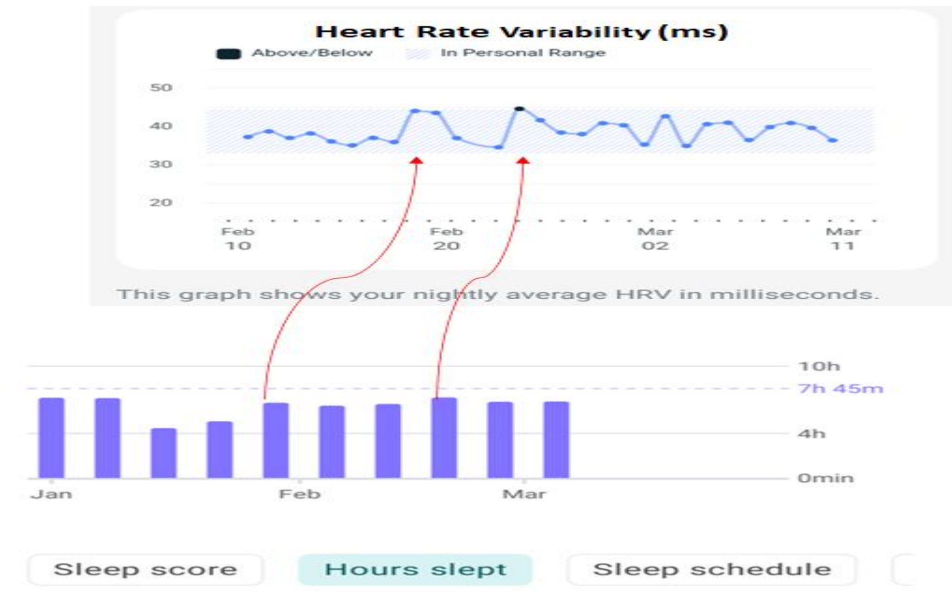
This graph shows your nightly average HRV in milliseconds.

This graph shows your nightly average BR in breaths per minute.

Further extending the example of HRV, it is possible to extrapolate and predict the values based on historical data and in correlation with other parameters as shown in figure below. This would serve as good alert for A to gauge whether she is slipping into chronic stress and take some proactive steps to improve their well-being.



Based on this data pattern, A can develop a well-being plan for herself and keep monitoring to ensure she doesn't slip into chronic stress situation. She is aware that good sleep (duration, quality etc) can relegate stress levels. As she notices HRV rates are falling, corroborated by her personal situation and other parameters she can plan interventions such as meditation, avoiding excess caffeine, and many other holistic healing & relaxation techniques to ensure good sleep. The resulting elevated HRV levels again corroborated with other parameters can be reassurance to her that the well-being interventions are working.



Annex D
(Informative)

Stress Management Concept – Pathology[1]

Stress may be defined as a real or interpreted threat to the physiological or psychological integrity of an individual that results in physiological and/or behavioral responses. Stress involves a stressor and a stress response. A stressor may be a physical insult, such as trauma or injury, or physical exertion, particularly when the body is being forced to operate beyond its capacity. Other physical stressors include noise, overcrowding, excessive heat or cold. Stressors also include primarily psychological experiences such as time-pressured tasks, interpersonal conflicts, unexpected events, frustration, isolation, and traumatic life events, and all these types of stressors may produce behavioral responses and evoke physiological consequences such as increased blood pressure, elevated heart rate, increased cortisol levels, impaired cognitive function, and altered metabolism.

Behavioral responses to stressors may decrease risk and get the individual out of trouble or involve health-promoting activities such as a good diet and regular exercise, but they may also include responses that exacerbate the physiological consequences of stress, for example, self-damaging behaviors like smoking, drinking, overeating, or consuming a rich diet, or risk-taking behaviors like driving an automobile recklessly.

The physiological stress responses include primarily the activation of the autonomic nervous system, leading to secretion of hormones (e.g. adrenalin, cortisol etc.) that mobilize energy required for flight-or-fight response. It is these physiological responses that have both protective and damaging effects. There are two important features of the physiological stress response: the first involves turning it on in amounts that are adequate to the challenge. The second is turning off the response when it is no longer needed. However, too much stress, or inefficient operation of the acute responses to stress, can cause wear and tear and exacerbate disease processes. There are enormous individual differences in interpreting and responding to what is stressful, as well as individual differences in the susceptibility to diseases, in which stress may play a role. Genetic pre-dispositions exist which increase the risk of certain disorders. In addition, developmental process, such as prenatal stress or nurturing or adverse early life experiences, contribute to the lifelong responsiveness of the behavioral and physiological responses to stressors. Furthermore, experiences throughout the life course resulting in memories of particularly unpleasant or pleasant situations combine with the genetic and developmental influences to produce large differences among individuals in how they react to stress and what the long-term consequences may be.

The perception of threat and mobilization of these mechanisms are fundamentally shaped by individual differences in constitutional (genetics, development, experience), behavioral (coping and health habits), and historical (trauma/abuse, major life events, stressful environments) factors that ultimately determine one's resiliency to stress (McEwen, 1998a)[2].

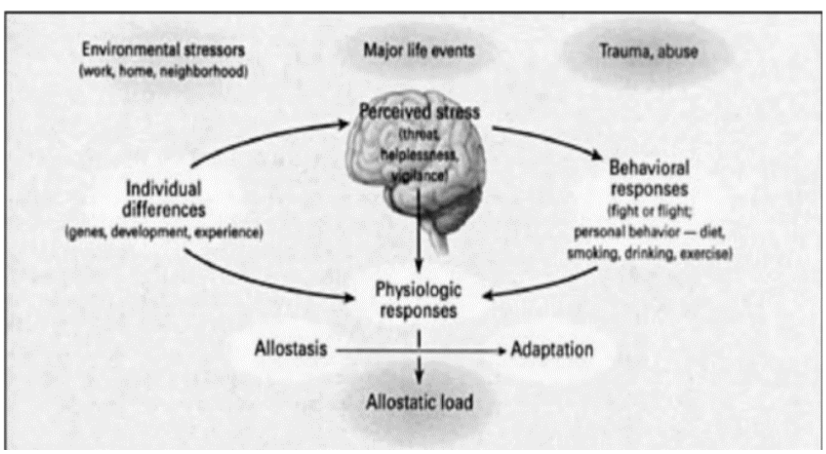


Figure 5: Role of individual differences in constitutional, behavioral and historical factors in one's resilience to stress

Chronic psychosocial stress and consequent physiological dysregulations are increasingly viewed as catalysts of accelerated aging and agitators of disease trajectories. Individual differences in the brain's interpretations of and the body's reactions to environmental stressors are nevertheless the ultimate determinants of either vulnerability towards or resilience against stress related diseases (Lupien et al., 2009; McEwen, 1998b, 2009). Health and successful aging can therefore be conceptualized as one's ability to adapt and effectively respond to the dynamic challenges of being alive.

There are a number of factors affecting stress (Stressors). Below is list of some of the stressors in various categories (not exhaustive list):

Table 3: List of factors affecting stress (Stressors)

Physical	**Environmental**	**Psychological**
● Trauma ● Injury ● Physical exertion	● Noise ● Temperature ● Lighting ● Air Quality ● Crowding ● Color ● Scents ● Visual clutter ● Natural / Artificial environments	● Time pressured tasks ● Interpersonal conflicts ● Unexpected events ● Frustration ● Isolation ● Traumatic life events

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