MORFAI JOURNAL Multidisciplinary Output Research For Actual and International Issue
INDEX COPERNICUS INTERNATIONAL
Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volumes 6 No. 6 (2026)

DESIGN OF AN IoMT-BASED REAL-TIME FITNESS MONITORING SYSTEM FOR OFFSHORE WORKERS AS AN EFFORT TO PREVENT ILLNESS-RELATED FATALITIES AT PT. X

Rinaldi Wiriadinata [1] *, Ivan Ali Sanjaya [2] , Iwan Vanany [3] , Ratna Sari Dewi [4] , Arief Rahman [5]
[1-5] Institute Technology November 10 Surabaya
E-mail: rinaldi.wiriadinata@pertamina.com

Received:10/06/2026 | **Revised** : 23/06/2026 | **Accepted:** 16/07/2026 | **Published:** 21/09/2026

Abstract

Operational industry upstream oil and natural gas , especially in the environment off offshore , has risk high health and safety . One of the problems that need to be addressed get attention is possibility occurrence *illness-related fatalities* consequence change condition physiological and *fatigue* that is not detected in a way early . System monitoring health conventional in nature periodic , including *pre-shift medical check-up* , have limitations in give information condition worker in a way continuous during activity operational . This engineering practice aims designing system monitoring fitness worker *offshore* in a way *real-time* based *Internet of Medical Things* (IoMT) with utilise device *wearable* in the form of integrated *smartwatch* with online *dashboard* . The method used covering survey field , *Focus Group Discussion* (FGD) with doctor company , identification problems , studies literature , design systems , development and integration , testing , and Analysis and evaluation of *fatality and illness* data 2021–2025 used For identify profile risk health workers . Design results produce integrated architecture *wearable devices* , networks communication , server, *dashboard* , and *early warning system* . Physiological parameters main designed For monitored covering *heart rate* (HR), *heart rate variability* (HRV), saturation oxygen (SpO_2), and *respiratory rate* (RR), while *blood pressure* (BP) is used as a supporting parameter . In 2025 there will be 13 workers with category *high* based on *Jakarta Cardiovascular Score* , 17 workers recorded as smokers , 8 workers experience hypertension , and 2 workers experiencing diabetes mellitus . The results strengthen need integration profile risk health with monitoring physiological in a way continuous . The system is designed potential speed up identification abnormal and supportive conditions taking decision power medical and HSE in implementation of *the fit to work* program . However , validation quantitative in the form of sensor accuracy , *latency* , *packet loss* , sensitivity , specificity , and *false alarm rate* Still need done at the stage implementation field next .

Keywords : IoMT, *wearable device* , *offshore* , *health monitoring* , *early warning system* , *fit to work* , HSE

INTRODUCTION

Industry upstream oil and gas , in particular activity operational *offshore* , is environment Work with characteristics complex risks . Workers operate activities in a relative location Far from facility health , facing pattern Work *shift* , demands physical and psychological , as well as condition environment dynamic work conditions the make health worker as one of the component important in management safety operational . Practice report engineering show that system monitoring ongoing health Still own limitations Because part big inspection done in a way periodic and not yet give description condition physiological worker in a way continuous when currently Work Problems the become the more important when associated with *fatigue* . Condition *fatigue* can develop during period work and not always can known through inspection health care that is carried out before worker start activity Research by Aria et al. (2024) on 67 workers *offshore* oil and gas in Indonesia shows that *acute fatigue* and *chronic fatigue* increase in a way significant during four Sunday period work , while *intershift recovery* experience decline . Findings the show that condition fitness worker nature dynamic and can changed after worker undergo activity during a number of day or Sunday .

Limitations system monitoring periodic create gap between condition health workers at the time inspection and condition current when worker operate activity . System inspection *pre-shift* can give information about conditions in a point time , but Not yet capable give information continuous about change physiological events that occur after worker entering the work area . Therefore that , is necessary approach capable monitoring catch change condition physiological in a way more continuous . Development technology *wearable devices* and *the Internet of Medical Things* (IoMT) provide opportunity For overcome gap the device . *wearable* can used as physiological data sources , while IoMT allows data to be sent through network communication going to system center For processed and visualized . In the design this , data from *smartwatch* sent in a way *real-time* to the server and displayed through *dashboard* so that power medical and team *Health, Safety, and Environment* (HSE) can get information condition worker without must wait next manual check . Need This is also supported by the profile health worker based on *Fatality Illness* data 2021–2025 period . Data shows existence combination various factor risks , including risks cardiovascular , habits smoking , BMI status, hypertension , and diabetes mellitus . In 2025 , as many as 13 workers is at in category *high* based on *Jakarta Cardiovascular Score* , 17 workers recorded as smokers , 8 workers is at in category hypertension , and 2 workers have diabetes mellitus .

Findings the show that monitoring health worker No Enough done based on One indicators . Profile risk historical need combined with information physiological actual so that the power medical get a clearer picture comprehensive . Therefore that , the system is designed in practice engineering This No only functioning as tool recording of physiological data , but directed become system supporters integrated decisions *data sensing* , transmission , processing , visualization , and *early warning* . Based on problem said , practice engineering This aim designing system monitoring fitness worker *offshore* in a way *real-time* IoMT based with utilise device integrated *wearable* with *dashboard* and mechanisms *early warning system* . System the expected can support supervision condition physiological workers , strengthening *fit to work* programs , and help power medical and HSE perform response more fast to conditions that require attention .

METHODOLOGY

Engineering practice use approach design and development system based need field . Stages activity covering survey field , identification and formulation problem , study literature , design IoMT systems , development and integration systems , testing , analysis and evaluation , as well as compilation report .

Survey Field and Identification Need

Early stage done through *Focus Group Discussion* (FGD) with doctor company PT. X as power experts . FGD focused on evaluation condition monitoring moderate health walk as well as identification the required physiological parameters needed For support effort subtraction risk fatality worker *offshore* .

Identification problem produce focus main in the form of limitations health monitoring system that is still nature periodic and not yet capable monitor change condition worker in a way *real-time* . Therefore that , the need system directed at monitoring physiological parameters in a way continuous and delivery information to power medical in a way fast .

Literature Study

Literature study done to technology *wearable devices* , IoT, health monitoring systems , and *early warning systems* . Literature obtained from journal scientific , standard international , as well as study previously used as base in determine design system and monitoring parameters .

Analysis Profile Health Risks

Statistical data *Fatality Illness* the 2021–2025 period is analyzed For get description profile health workers . The variables used covering age , *Jakarta Cardiovascular Score ,* smoking status , BMI, hypertension , and diabetes mellitus . The data No used as substitute for *real-time* monitoring , but as profile complementary risks information physiological actual .

Design System

Architecture system consists of on three component main , namely device *wearable* or sensors, networks communication and *dashboard* as monitoring center . Under development more further , architecture the connected with servers/ data centers and mechanisms *early warning system* . The main parameters designed includes HR, HRV, SpO_2, and RR, while BP is placed as a supporting parameter .

Data flow is designed with pattern :

Workers → *Wearable Devices* → Networks Communication → Server → *Dashboard* → Analysis Condition → *Early Warning* → Medical Team / HSE.

Development , Integration, and Evaluation

Development stage done with integrate *smartwatch* with *online dashboard* . Physiological data sent in a way *real-time* to the server and visualized so that can accessible power medical . Testing designed covers sensor data accuracy , stability transmission , as well as response system when happen health parameter anomalies . Evaluation system done with compare monitoring function with need *early warning system* . However , the report Not yet provide numerical data about sensor accuracy , *latency* transmission , *packet loss* , sensitivity , specificity , or *false alarm rate* . Therefore , the parameter Not yet can reported in form percentage success .

RESULTS AND DISCUSSION

Profile Worker Health Risks

Fatality Illness data analysis show that risk health worker *offshore* nature multifactorial . Data includes a number of interrelated indicators related , namely age , risk cardiovascular , habits smoking , BMI, hypertension , and diabetes mellitus . Conditions the become base that monitoring system is necessary combine profile health with physiological data actual .

Profile Risk Cardiovascular

Distribution *Jakarta Cardiovascular Score* show existence worker in category *high* throughout period 2021–2025. Amount worker category *high* respectively are 11 people in 2021, 15 people in 2022, 7 people in 2023, 8 people in 2024, and increasing to 13 people in 2025.

Table 1. Distribution of Jakarta Cardiovascular Score 2021–2025

Year	Low	Medium	High	No Data
2021	4	3	11	2
2022	5	6	15	0
2023	1	7	7	1
2024	5	6	8	0
2025	1	6	13	0

Source : Statistical Data *Fatality Illness* 2021–2025.

Improvement return category *high* in 2025 strengthens need monitoring of related parameters with system cardiovascular , especially HR and HRV. *Jakarta Cardiovascular Score* in system No positioned as measurement *real-time* , but as information risk historical that can used in interpretation of physiological data .

Smoking Status

Smoking status show variation during period observation . In 2021 there will be 9 workers smokers , increasing to 15 in 2022, 13 in 2023, 10 in 2024, and back increase to 17 workers by 2025.

Table 2. Smoker Status 2021–2025

Year	Smoker	No	No Data
2021	9	9	2
2022	15	11	0
2023	13	2	1
2024	10	9	0
2025	17	3	0

Source : Statistical Data *Fatality Illness* 2021–2025.

Smoking status No designed as a measured parameter in a way directly by *smartwatch* . Information the placed as part from profile health stored workers in the database and used as information supporters when power medical do interpretation condition physiological .

BMI Status

BMI data shows variation distribution condition Worker weight . In 2021, 10 workers were recorded in the category first shown in source , 2 in category second , and 6th in the category Third . In 2025, there will be 6 workers in the category first , 4 in category third , and 9th in the category fourth . Because the label is all categories on the graph source No fully visible , report maintain classification based on order category without give interpretation addition to categories that do not identified in a way explicit .

Table 3. Distribution of BMI Status Based on Graphic Data

Year	Category 1	Category 2	Category 3	Category 4	Category 5
2021	10	2	6	0	2
2022	9	2	2	13	0
2023	5	4	1	5	1
2024	8	3	2	6	0
2025	6	0	4	9	1

Source : Statistical Data *Fatality Illness* 2021–2025.\

Hypertension Status

In 2025 there will be 11 workers with normal status, 1 worker with prehypertension status , and 8 workers with hypertension status .

Table 4. Hypertension Status 2021–2025

Year	Normal	Prehypertension	Hypertension	No Data
2021	11	3	6	3
2022	16	2	8	0
2023	9	3	3	1
2024	12	0	7	0
2025	11	1	8	0

Source : Statistical Data *Fatality Illness* 2021–2025.

The presence of 8 workers with hypertension status in 2025 to become one of base enter BP as a supporting parameter in design system . However , the hypertension status obtained from inspection health must differentiated from physiological monitoring results *Real-time* . Hypertension status is part from *risk profile* , while *real-time* monitoring aim catch change condition physiological actual .

Diabetes Mellitus Status

In 2025 there will be 17 workers in normal category , 2 workers with diabetes mellitus , and 1 data that is not available .

Table 5. Diabetes Mellitus Status 2021–2025

Year	Diabetes	Normal	No Data
2021	5	13	2
2022	3	23	0
2023	1	14	1
2024	8	11	0
2025	2	17	1

Source : Statistical Data *Fatality Illness* 2021–2025.

Diabetes information is not designed as the main parameter *wearable* , but can saved as part from profile health workers and used as context addition when power medical evaluate change physiological .

Designed Physiological Parameters

Identification results need produces five physiological parameters that are considered in system , namely HR, HRV, SpO_2, RR, and BP. HR is used For monitor response and load cardiovascular , HRV for give information about variation pulse heart as well as response system nerve autonomous , SpO_2 for monitor saturation oxygen , RR for monitor condition respiration , and BP as information related condition cardiovascular .

Table 6. Physiological Parameters in Monitoring System

Parameter	Normal Range / Reference	Monitoring Function
HR	60–100 bpm at Rest	Monitoring response and load cardiovascular
HRV	Varies based on individual	Monitoring stress , *fatigue* , and recovery
SpO_2	95–100%	Detecting potential hypoxemia
RR	12–20 times/ minute	Monitoring condition respiration
BP	<120/<80 mmHg as normal reference	Monitoring risk hypertension / hypotension and conditions cardiovascular

Design Get up IoT System

Design system connect *wearable device* with centralized digital system . Architecture consists of on device measurement , network communication , server/ data center , *dashboard* , and users end . *Wearable device* functioning as physiological data sources . Planned devices in the form of *smartwatch* that can do measurement of physiological parameters certain without bother activity workers . Further data sent through network communication to the server and displayed on *the dashboard* . *Dashboard* functioning as center visualization and monitoring. System designed for power medical and HSE can view worker status , changes in physiological parameters , as well as get notification if found conditions that require attention .

The Need for Regular Health Monitoring Continuous

Practical results show that need main system No solely obtain health data workers , but change the data become information that can used in a way fast by power medical and HSE. Examination periodic own limitations Because condition physiological worker can changed after inspection done . Because of that that , continuous monitoring become approach which is relevant For environment Work *offshore* . Findings the in line with Aria et al. (2024), which shows that *acute fatigue* and *chronic fatigue* in workers Indonesia's *offshore sector* is increasing during four Sunday period work , while *intershift recovery* decreased . With Thus , the condition workers at the time inspection beginning No always describe condition after undergo period Work . Kang et al. (2026) also show that rotation *shifts* on workers *offshore* related with change sleep , *sleepiness* , and performance alertness . Condition the strengthen need monitoring approach that is not only depends on the examination before Work .

HR and HRV as Monitoring Indicators

HR is one of the main parameters in design system Because can give information about response cardiovascular during activity . Meanwhile that , HRV provides information addition about pulse interval variation heart and response system nerve autonomous . Use both parameters in together can give a clearer picture informative compared to only use one parameter. Research by Jacobs et al. (2024) shows that the HR sensor is worn on the wrist hand can used as part from *whole-body fatigue* monitoring approach in workers field . In the context of design In this , HR and HRV are used as part from source information combined physiological with other parameters .

SpO_2 and Respiratory Rate

SpO_2 and RR are used as indicator supporters For monitor condition respiration . System No directed For make One abnormal reading as a medical diagnosis . If SpO_2 value is outside limits , systems need consider abnormal duration , repetition reading , combination with RR and HR, as well as condition activity workers . Approach the required For reduce possibility *false positive* . With Thus , *an early warning system* should No use logic simple in the form of one parameter passed limit certain . System more appropriate use approach based patterns and parameter combinations so that warning given more relevant For done verification by personnel medical .

Blood Pressure and Challenges Wearable Validation

BP is an important parameter because of health data worker show existence worker with hypertension status . However , BP measurement through device *wearable* own challenge separately . The report emphasizes that technology *cuffless blood pressure monitoring* Still development and validity measurement can different between devices . Therefore that , BP should placed as *supporting monitoring parameters* . Abnormal results from *wearable* No may in a way automatic translated be diagnosed with hypertension or decision that worker No worthy work . The results need verified use method measurements are appropriate and have been validated .

Profile Integration Real-Time Risk and Data

One of contribution main design is combining historical data with physiological data actual . Data such as *Jakarta Cardiovascular Score ,* smoking status , BMI, hypertension , and diabetes can be saved as profile risk workers . Meanwhile that , HR, HRV, SpO_2, RR, and other parameters become source information about condition physiological actual . Approach This more appropriate Because risk health worker nature multifactorial . Data for the 2021–2025 period shows existence combination factor risk like risk cardiovascular height , smoking , hypertension , and certain BMI conditions . With integration said , the system No only functioning as system recording , but can developed become system supporters decision .

Early Warning System

Early warning system is part important Because changing physiological data become information that can followed up . System can compare data with mark reference or *baseline* workers . If found abnormal pattern , system give notification to power medical or HSE. However , the notification the must understood as signal For do verification , not automatic diagnosis . *Dashboard* can use classification information such as normal, *warning* , and *critical* . The most important information must can seen with fast so that power medical can determine priority action continue . With thus , *dashboard* No just become a visualization medium , but become part from *clinical decision support* .

Implications towards the Fit to Work Program

Designed monitoring system can strengthen approach *fit to work* with give information condition worker in a way more dynamic . Assessment *fit to work* which is only done through inspection *pre-employment* or inspection periodically own limitations Because No describe condition current workers at every time during operate job . With availability of physiological data in a way continuous , power medical can get information addition For determine whether required rest , examination more continue , or action medical / evacuation in accordance condition . System still functioning as tool help and not replace authority professional power health in take decision .

Aspect Data Quality and Validation

Success IoMT system does not only determined by ability device send data via *real-time* , but also by the quality of the data received . The system need capable distinguish between valid data and invalid data complete , data not reasonable , and the data required verification . One of the proposed approach is giving *data quality flag* on *the dashboard* . This become important especially on parameters such as BP and SpO_2 which can influenced by sensor quality , position devices , activities , and conditions users . Therefore that , stage implementation next need covers testing quantitative about accuracy , *latency* , *packet loss* , sensitivity , specificity , and *false alarm rate* . The report that becomes base article This Not yet provide numerical data for those parameters so that No done claim quantitative about level success system .

Design system own a number of implications engineering . First , the system integrating *data acquisition* , *data transmission* , *data processing* , *data visualization* , and *decision support* processes in One architecture . Second , the use of *wearable device* allows physiological data collection in a way more continuous without require worker do repeated manual checks . Third , *the dashboard* allows power medical and HSE monitor the a number of worker in a way more efficient . From the side safety , system must designed to not produce risk new . Health data worker is information sensitive so that aspect security and privacy need be noted . The report also places professionalism , ethics profession , safety and health work , and sustainability and innovation as principle implementation engineering

CONCLUSION

Engineering practice This produce design system monitoring fitness worker *offshore* in a way *real-time* IoMT based that integrates *wearable devices* , networks communication , server, *dashboard* , and *early warning system* . System designed For overcome limitations of health monitoring conventional in nature periodic and not yet capable give information condition physiological worker in a way continuous . Analysis of *Fatality Illness* data 2021–2025 shows that worker own profile risk diverse health . In 2025 there will be 13 workers with category *high* based on *Jakarta Cardiovascular Score* , 17 workers recorded as smokers , 8 workers is at in category hypertension , and 2 workers having diabetes mellitus . Condition the show importance monitoring approach that takes into account combination factor risk history and conditions physiological actual .

The main parameters designed for monitoring are HR, HRV, SpO_2, and RR, while BP is used as supporting parameters . Integration of these parameters with profile risk workers and *dashboard* give base for development *early warning system* that can help power medical and HSE perform identification early to change condition worker . Designed system own potential support *the fit to work* program through provision information physiological in a way more continuous . However , the system No intended For replace examination and decision clinical . The resulting alert must treated as signal For verification and action continued by manpower professional . Implementation next need focused on validation field in a way quantitative , especially sensor accuracy , stability transmission , *latency* , *packet loss* , sensitivity , specificity , and *false alarm rate* . Validation the required for the system can assessed in a way objective before used as part from taking decision operational .

REFERENCES

Aria, M., Khazim, I., Ilyas, M., Kekalih, A., & Fuady, A. (2024). Work-related fatigue among Indonesian offshore oil and gas workers. *Occupational Medicine, 74*(5), 364–369. https://doi.org/10.1093/occmed/kqae040.

Chan, M., Estève, D., Escriba, C., & Campo, E. (2012). A review of smart homes—Present state and future challenges. *Computer Methods and Programs in Biomedicine*, 91(1), 55–81. https://doi.org/10.1016/j.cmpb.2008.02.001

Dawson, D., & McCulloch, K. (2005). Managing fatigue: It's about sleep. *Sleep Medicine Reviews*, 9(5), 365–380. https://doi.org/10.1016/j.smrv.2005.03.002

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645–1660. https://doi.org/10.1016/j.future.2013.01.010

Islam, S. M. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The Internet of Things for health care: A comprehensive survey. *IEEE Access*, 3, 678–708. https://doi.org/10.1109/ACCESS.2015.2437951

Jacobs, J., et al. (2024). Wearable heart rate sensing and critical power-based whole-body fatigue monitoring in the field. *Applied Ergonomics, 121*, 104358. https://doi.org/10.1016/j.apergo.2024.104358.

Jiang, Y., et al. (2023). Investigating the accuracy of blood oxygen saturation measurements in common consumer smartwatches. *PLOS Digital Health*. https://doi.org/10.1371/journal.pdig.0000296.

Kang, J., Payne, S. C., Sasangohar, F., & Mehta, R. K. (2026). The impacts of rotating shiftwork on worker fatigue levels and associated adaptations: A naturalistic study across offshore platforms in the Gulf of Mexico. *Human Factors, 68*(1), 109–122. https://doi.org/10.1177/00187208251358635.

Kumar, P., Lee, H. J., & Lee, H. G. (2020). E-health monitoring system using IoT and smart wearable devices. *International Journal of Advanced Computer Science and Applications*, 11(5), 1–7.

Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons*, 58(4), 431–440. https://doi.org/10.1016/j.bushor.2015.03.008

Non-invasive blood pressure monitoring using wearables for cardiovascular risk assessment: A systematic review. (2025). *Journal of Medical Internet Research/related cardiovascular monitoring literature*.

Paech, G. M., et al. (2019). Time-of-day and days-on-shift predict increased fatigue over two-week offshore day-shifts. *Sleep Health*.

Pantelopoulos, A., & Bourbakis, N. G. (2010). A survey on wearable sensor-based systems for health monitoring and prognosis. *IEEE Transactions on Systems, Man, and Cybernetics*, 40(1), 1–12. https://doi.org/10.1109/TSMCC.2009.2032660

Patel, S., Park, H., Bonato, P., Chan, L., & Rodgers, M. (2012). A review of wearable sensors and systems with application in rehabilitation. *Journal of NeuroEngineering and Rehabilitation*, 9(21), 1–17. https://doi.org/10.1186/1743-0003-9-21

Piwek, L., Ellis, D. A., Andrews, S., & Joinson, A. (2016). The rise of consumer health wearables: Promises and barriers. *PLoS Medicine*, 13(2), e1001953. https://doi.org/10.1371/journal.pmed.1001953

Rae, D. E., et al. (2021). The association between heart rate variability, reaction time, and indicators of workplace fatigue in wildland firefighters. *International Archives of Occupational and Environmental Health*. https://doi.org/10.1007/s00420-020-01641-3.

Reason, J. (2000). Human error: Models and management. *BMJ*, 320(7237), 768–770. https://doi.org/10.1136/bmj.320.7237.768

Shaffer, F., & Ginsberg, J. P. (2017). An overview of heart rate variability metrics and norms. *Frontiers in Public Health*, 5, 258. https://doi.org/10.3389/fpubh.2017.00258

Steinhubl, S. R., Muse, E. D., & Topol, E. J. (2015). Can mobile health technologies transform health care? *JAMA*, 310(22), 2395–2396. https://doi.org/10.1001/jama.2013.281078

Williamson, A., Lombardi, D. A., Folkard, S., Stutts, J., Courtney, T. K., & Connor, J. L. (2011). The link between fatigue and safety. *Accident Analysis & Prevention*, 43(2), 498–515. https://doi.org/10.1016/j.aap.2009.11.011

Windisch, P., Schröder, C., Förster, R., Cihoric, N., & Zwahlen, D. R. (2023). Accuracy of the Apple Watch Oxygen Saturation Measurement in Adults: A Systematic Review. *Cureus, 15*(2), e35355. https://doi.org/10.7759/cureus.35355.

World Health Organization. (2020). *Occupational health: A manual for primary health care workers*. WHO Press.

World Health Organization. (2021). *Global strategy on occupational health for all*. WHO Press.

World Health Organization. (2025). *Cardiovascular diseases*. WHO.

World Health Organization. (2025). *Global report on hypertension 2025: High blood pressure—turning evidence into action*. WHO.
World Health Organization. (2025). *Hypertension*. WHO.
World Health Organization. (2025). *Noncommunicable diseases*. WHO.