Health Technologies for Detecting High-Risk Conditions in Pregnancy: A Literature Review

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Abstract

In this technological era, various health technology including media, instruments, and tools are created in area maternal and babies' health. However, comprehensive information about these technology products is limited. This review aimed to find health technology in area maternal and baby especially in detecting high-risk conditions in pregnancy. Methods, this is a literature review, the articles were searched from two databases including PubMed and CINAHL using several keywords. The keywords were high risk, pregnant women and technology OR instrument OR tools. Inclusion criteria are primary research, English language, and publications in the last 5 years. After the critical appraisal, a total of 16 articles included in the analysis. Result: The literature related to technology divided into two criteria which are the questionnaire development and health tools or devices. None of the technology came from Indonesia. The entire technology showed effectiveness in detecting risks, and interventions to improve prenatal care. The target user for health tools mostly health professionals. Conclusion: various health technologies in area maternal and baby health are identified, however, the majority of them provided from health professionals. Technology development is needed specifically, in the form of simple and practical tools or devices to assess foetal health with target user is pregnant women with high-risk pregnancy.

Keywords: Foetal health, health technology, high-risk pregnancy.

Introduction

Technological developments in health areas are invented along with the development of science in the world. Development of technology is one indicator of improvement in a country (Ngafifi, 2014). Health technology includes all types of the invention that have developed in the health sector for the purpose of promotion, prevention, screening, enforcement of diagnosis, treatment, rehabilitation, and long-term care. The technology includes medicines, medical devices and tools, medical and surgical procedures, support systems, and organizational and managerial systems (Ministry of Health, Republic of Indonesia, 2017). In addition to medical devices, health technology also includes action procedures with the aim of promotion to long-term palliative care.

The health technology products are varied, however, it's still limited In Indonesia. The most are imported from other countries than domestically produced. One of the technologies in the health sector that is developing in Indonesia, namely e-health. E-health is a health service that refers to information and communication technology, to help people receive health care services efficiently, effectively, and safely (Nugraha & Akunuranda, 2017; Nasution & Hariyanti, 2018). In addition to e-health, there are other technologies used to support health services, especially maternal services such as ultrasonography (USG), Doppler, magnetic resonance imaging (MRI) and so on. Several health technologies are available, aiming to detect various risks in pregnancy with target users are health workers.

Pregnancy with high-risk cases includes hypertension in pregnancy (pre-eclampsia and eclampsia), gestational diabetes, bleeding, placental abnormalities, and infection are risky health conditions for mothers and babies. The high risks may happen because of several risk factors including obesity, substance abuse, and drugs, smoking, lack of nutrition, pregnancy at the age of too young or too old, and trauma (Durham & Chapman, 2014). High-risk pregnancies will increase morbidity, disability and mortality, both mother and baby, these conditions can be prevented by early detection. According to WHO, around 830 women die every day related to pregnancy and childbirth and 99% occur in developing countries (WHO, 2018). This death is caused by several preventable causes if it has been detected from the beginning of pregnancy. Early detection of high risks in pregnancy is significant using health technology, various health technology including media, instruments, and tools are created in area maternal and babies' health. However, comprehensive information about these technology products is limited. This literature review aimed to find health technology in area maternal and baby especially in detecting high-risk conditions in pregnancy.
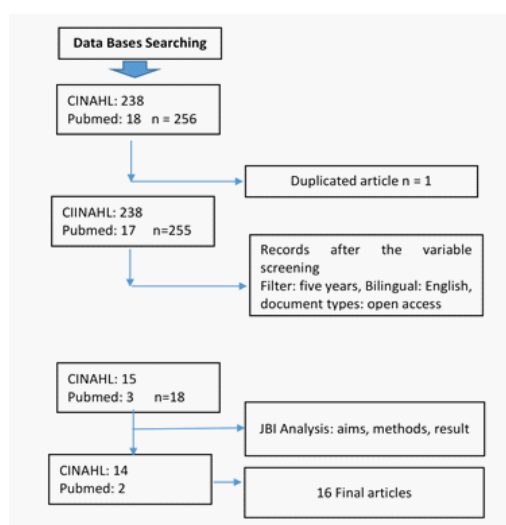
Research Method

Diagram 1 Article selection processes

This study is a literature review. Articles searched from two databases including PubMed and CINAHL. The keywords for article searching were at high risk, pregnant women, and technology OR instrument OR tools. Inclusion criteria were primary research, English language, and publications in the last 5 years. 256 articles were found based on keywords and continued with screening based on inclusion criteria. A total of 18 articles met the inclusion criteria. Furthermore, an analysis using JBI tools was carried out, including components of objectives, methods, samples and settings, criteria and results. Final articles for further analysis of 16 articles. An article summary is presented in the table (table.1) and analysis of article content in the report in the discussion section. Steps for determining articles (Diagram 1).

Research Results

The technologies are varied, many researchers have developed a questionnaire or a format to assess or early detection of high risks in pregnancy, other studies developed health tools or instruments. The majority study was targeted health workers as the user, and only 2 studies declared that their studies targeted patients (pregnant women) as the user. The high-risk problems in pregnancy include the risk of genital infection, psychological, Diabetes Mellitus infection, preterm labor, these health problems are detectable and preventable. Most research was carried out using quantitative approaches, and minimal qualitative studies. Research settings were in developing countries, however none of them from Indonesia.

The literature search found 16 relevant articles, the articles about technology to detect problems, high risks, and abnormalities during pregnancy. 10 articles are instrument or tools, and 6 articles are questionnaires and format .

Title/Year	Author	Country	Design	Sample	Intervention	Instrument	Results
vel point-of-care g strategy for lly transmitted ions among ant women in burden settings: s of a feasibility in Papua New ea (2016)	Badman. SG, Vallely. LM, Toliman. P, Kariwiga. G, Lote. B, Pomat. W	Papua New Guinea	Descriptive Exploratory study	125 pregnant women	Participants received routine antenatal and provider-initiated HIV and syphilis screening, and hemoglobin estimation. After that, participants provided two self-collected, mid-cavity, vaginal swabs for on-site testing: CT/NG and TV using the GeneXpert platform; and BV using the BVBlue rapid test assay.	GeneXpert platform a BVBlue rapid test assay.	Genexpert device has the potential to diagnoses quickly and changes the way STI's in pregnancy is managed and reduce the number of associated adverse health outcomes for antenatal women in Papua New Guinea.
tal screening for osocial risks in n risk-population ru using the DEX interview)	Spyridou. A, Schauer. M and Leuschner M. R	Lima, Peru	Descriptive Exploratory study	95 pregnant women	Interviews about psychosocial aspects using the KINDEX assessment to assess stress, psychopathology and the burden of trauma.	KINDEX	KINDEX is feasible for psychological screening of pregnant women. In using the KINDEX, the medical staff will be able to detect stress, psychopathology and trauma experiences and identify high-risk women.
Antenatal tion of tional tes in Obese en: Development tion Tools for ted Intervention)	White. S. L, et al.	United Kingdom	Prospective cohort study	1303 pregnant women	Maternal anthropometric data and blood pressure (BP) measurements were undertaken by staff trained in these measurements. After that, the GDM group was assessed using models developed as predictors.	Anthropometric analysis for basic tools development	This research shows that the results of a comprehensive study are useful for developing tools to identify pregnant women with GDM more complete and inexpensive.

Screening methods for obstructive sleep apnoea in severely obese pregnant women (2017)	McCallin .L, et al.	United Kingdom	Quantitative study	162 pregnant women	BMI respondents> 35 attended antenatal care three times during pregnancy, filled in the ESS each visit, the second visit measured AHI, at 16, 28 and 36 weeks gestation.	Epworth Sleepiness Scale (ESS) questionnaire	The accuracy of the ESS questionnaire, particularly the RU monitor, to screen f OSA in the pregnan population remains unclear.
Validation of the High-Risk Pregnancy Stress Scale in a sample of hospitalized Greek high-risk pregnant women (2016)	Gourounti. K, et al.	Greece	Quantitative study	133 pregnant women	The HRPSS was used to measure antenatal stress and consists of sixteen items that ask women to indicate her degree of stress for the different situations presented.	High-Risk Pregnancy Stress Scale (HRPSS), State-Trait Anxiety Inventory (STAI)-State, Edinburgh Postnatal Depression Scale (EPDS)	The HRPSS is an appropriate measur assessing the levels of concerns regarding pregnanc outcome, movemen restriction, isolation and external activity restrictions in Gree high-risk pregnant women.
Virtual visits: Managing prenatal care with modern technology `(2016)	Pflugeisen. B. M., et al.	USA	Cohort study	1,058 pregnant women	Virtual Visits is scheduled for 30 minutes each visit and tend to last 15 to 20 minutes, but on occasion Virtual Visits have lasted as long as 45 minutes.	Videoconferencing technology	The Virtual Visit program provides lo risk pregnant wome with a new model o prenatal care. Our results suggest it do not increase the risk for mother or baby compared to a traditional mode
Is TWEAK a valid screening questionnaire to identify alcohol risk drinkers among pregnant women in Denmark?	Pia. C & Ulrik	Denmark	Cohort study	1895 pregnant women	Two questions were included in the interview assessing tolerance, namely a "hold"-version and a "high"-version. The hold-question was used for assessing periconceptional risk drinking, while the high-question was used for assessing risk drinking during pregnancy.	TWEAK questionnaire	TWEAK does not seem to be an optim screening tool to ide periconceptional ris drinkers, but it may be more useful for identifying high-risk drinking during pregnancy and easy administer by health practitioners as part antenatal care
Automated electrogastrographic detection of uterine contractions for monitoring of pregnancy: feasibility and prospects. (2018)	Muszynski. C, et al.	France	Retrospective study	51 pregnant women	A system of 18 Ag/AgCl surface electrodes was used by placing 16 recording electrodes between the woman's pubis and umbilicus according to a 4 × 4 matrix and two reference electrodes on each of the woman's hips. Electrical signals were recorded at a sampling frequency of 200 Hz and were then transferred by Wifi to a laptop computer for processing by TMSi PolyBench® software.	Electrohysterographic	Electrohysterograph suitable for monitor of uterine contractio possibly at home, allowing telemonito of pregnancies. One the advantages of E processing is that us information concern contraction efficienc can be extracted fro this signal.

of pregnancy ...ound before ...9th-week scan: ...alytical study ... on the Icelandic ...birth and Health ...rt (2018)	Halle. K.F, et al.	Iceland	Cross-sectional cohort study	1.111 pregnant women	Participating women answered a comprehensive questionnaire around pregnancy week 16 (phase I). Phase II was conducted 5–6 months postpartum (765 participants responded), and phase III 18 to 24 months after delivery (657 participants, i.e. 59% of the original 1111 sample).	Ultrasound	Scanning ultrasound can be used in high and low-risk pregnancies, to prenatal screening for foetal anomalies
...tegrated with ...MR method for ...sing structural ...abnormalities and ...uring intracranial ...es in fetuses ...congenital heart ...se: results of a ...ective case-...ol feasibility study ...)	Griffiths. P. D, et al.	USA	Case-control	16 pregnant women	All iuMR imaging studies were performed on the same 1.5-T whole body scanner (HDx, GE Healthcare, Milwaukee) using an eight-channel cardiac coil positioned over the maternal abdomen. Scan time is around 20-24 seconds.	Integrated in utero MR	iuMR can thoroughly investigate all intracranial compartments in fetuses with CHD in clinically appropriate scan times, the fetus has a high risk of structural abnormalities and smaller brain volume when the results of ultrasound of the brain are normal.
...mated Detection ...emature Delivery ...g Empirical ...e and Wavelet ...et Decomposition ...niques ...Uterine ...romyogram ...ls (2017)	Acharya .U R, et al.	Singapore	Quantitative study	300 pregnant women	The process is carried out sequentially were pre-processing, Empirical Mode Decomposition (EMD), Wavelet Packet Decomposition (WPD, data balancing using ADASYN, feature selection and ranking, dan classification.	New algorithm using Empirical Mode Decomposition (EMD)	The EMD combined with WPD can categorize the two classes with an accuracy of 96.25%, the sensitivity of 95.08% and specificity of 97.33% using 10 uterine EMG signal features with 10-fold cross-validation. It is easy to operate and cost-effective
...nnovative ...le Health ...m to Improve ...tandardize ...natal Care ...g Underserved ...munities: A ...bility Study in an ...n Hosting Center ...sylum Seekers ...)	Borsari. L, et al.	Italy	Quantitative study	150 pregnant women	The system includes three components: The PANDA app, The Point of Care (PoC), The Medical Unit. Evaluation of the feasibility of the PANDA mHealth system, by exploring the functionality of the technologies (using the Redmine tool) and the acceptability of the system by the recipients.	Smartphone, Redmine tool.	mHealth application: The Pregnancy and Newborn Diagnostic Assessment (PANDA) proven to be effective for increasing health care providers with recommendations for antenatal care, facilitate women's involvement and retention of health education modules.
...renatal screening ...–13+6 weeks in ...ed reproductive ...ology singleton ...ancies and those ...ived naturally ...)	Gong. M, Shi. H, Zhang. Y and Ming. L	China	Retrospective study	2.034 pregnant women	Ultrasound mechanical index and soft-tissue thermal index were maintained at 1.0 and 0.5 throughout the inspection process. In addition, maternal blood samples were collected on the same day of ultrasound screening, for measurement of serum plasma protein-A (PAPP-A) and free β-human chorionic gonadotropin (fβ-hCG) concentration.	Ultrasound	ART does not increase the risk of fetal chromosomal abnormalities. And, compared with the naturally conceived fetus, ART fetuses are larger, but the exact factors and the impact on the following trimester are unclear.

Sex differences in fetal heart rate and variability assessed by antenatal computerized cardiotocography (2014)	Bhide. A and Acharya. G	London	Retrospective cross-sectional study.	7 4 0 pregnant women	The electronic database of our fetal assessment unit to retrieve cCTG records. Gestational age at the CTG recording, time of theday at the start of the recording and the recording duration were retrieved. Information on pregnancy outcome was obtained from the electronic medical records using the hospital´s maternity database. Fetal sex was ascertained from the birth records	cCTG	Male fetuses a significantly baseline heart rate greater variability compared to fe fetuses. However the absolute differ are small, they not be of major cl significance.
Validity and reliability of the Turkish version of the Optimality Index-US (OI-US) to assess maternity care outcomes (2015)	Yucel. C, Taskin. L, Low L. K	Turkey	Quantitative study: content validity	3 0 0 pregnant women	The study sample size required is calculated based on the number of items on the OI-TR. Five participants were included in the study for each item.	Optimality Index-US (OI-US)	OI-TR is a vali that can be used to a pregnancy care.
One-step simultaneous detection of Ureaplasma parvum and genotypes SV1, SV3 and SV6 from clinical samples using PlexPCR technology	Payne. M. S, et al.	Australia	Retrospective cohort study	1 8 8 pregnant women	This study compared the new PlexPCR UP assay with results from our previously developed U. parvum HRM assay, as used in our recent study that investigated vaginal colonization by a range of microbes and association with preterm birth	PlexPCR technology	The Plex was highly sens detecting all targe between 0.4 x 10-DNA (SV3) and 0.4 10-6 ng DNA parvum, SV1 and S

Discussion

Various technologies are found from articles, the technology divided into two categories which are assessment tools in the form of questionnaires, and health instruments or devices. Most of the technology is targeted health professionals, and very few of them have targeted pregnant women or post-partum. Articles of health technology development originated from outside Indonesia, none studies originating from Indonesia, so maybe the main causes of maternal and baby morbidity and mortality are different. In Indonesia, other and foetus are threatening several risks for example preeclampsia, infection, bleeding, foetal conditions such as LBW or premature, and other congenital diseases. Questionnaires and health tools from articles are discussed below:

Questionnaires and format of assessment

There are two articles that have developed a format to detect anxiety, the experience of stress and trauma in pregnant women. The Spyridou et al., (2016) study developed an appropriate KINDEX assessment for prenatal screening. With KINDEX, medical staff can detect experiences of stress, psychopathology, trauma, and identify high-risk pregnant women. The format helps health workers too, so they can determine the decision to be referred patients, easily. In addition, a stress assessment questionnaire was found in pregnant women that developed in Greece, namely the High-Risk Pregnancy Stress Scale (HRPSS). HR PSU is the right step to assess the level of concern about pregnancy outcomes, restrictions on movement, isolation, and restrictions on external activity in high-risk pregnant women in Greece (Gourounti et al., 2016). Pregnant women may experience stress due to various factors, which if not treated immediately, it may be affected by women and foetal. These two questionnaires are useful to detect anxiety, the experience of stress and trauma from the beginning of pregnancy.

In addition, pregnant women who are obese would also be at high risk for several health problems or diseases, such as diabetes. Diabetes in obese pregnant women can be detected by a questionnaire developed by White et al., (2016). This study shows a method to identify more accurately obese women who are at high risk of developing diabetes, rather than the methods currently used. In addition, obese pregnant women are at risk of developing obstructive sleep apnea (OSA). To detect OSA, the researcher can use the Epworth sleepiness scale (ESS) questionnaire. The National Institute of Clinical Excellence (NICE) recommends the ESS questionnaire as a screening tool for non-pregnant populations too, with referral recommendation if symptoms are added to an ESS score of> 10 (Longworth et al., 2017). Pregnant women with obesity, have risks for various problems or diseases, so it should be considered and detected early. The developed questionnaire can be used to detect the risk of developing diabetes and obstructive sleep apnea (OSA), obese pregnant women can detect early for risks from any health problems. However, for the ESS questionnaire, the accuracy of the RUS monitor for filtering OSA in the pregnant female population is still unclear. Thus, it is hoped that there will be further research on larger sample sizes and use more user-friendly technology to measure apnea hypopnoea index (AHI) with confidence.

Pregnant women who have a habit of consuming alcohol can also be at risk for pregnancy. Camilla et al., (2016), investigated the ability of the TWEAK (Tolerance, Worries, Eye-opener, Amnesia, and Kut-down) questionnaire to identify the risk of alcohol consumption in pregnant women. TWEAK is used as a screening tool in identifying alcohol risk in pregnant women because it is easily managed by health practitioners as part of antenatal care (Camilla et al., 2016). With the TWEAK questionnaire, it is easy for us to detect the risk of alcohol in pregnant women who have a habit of consuming alcohol. However, TWEAK cannot always apply to different populations directly, so it needs to be developed again for widespread use.

To assess the results of prenatal care, Yucel et al. (2015) in Turkey adapted the US Optimality Index (OI-US) to the Optimality Index-TR (OI-TR). OI-TR is a valid tool that can be relied upon to assess pregnancy care. With OI-TR, the results of prenatal care can

be assessed, so that it can detect possible risks that can occur. However, this can only be used in Turkey, so further research is needed to develop this questionnaire, adapted to the conditions and culture in Indonesia. From the six questionnaires, several questionnaires may be not suitable with the health problem of pregnant women in Indonesia. The pregnant women in Indonesia are at risk of malnutrition, infectious and viral diseases, bleeding, preeclampsia, and violence. Development Formatting or questionnaire research is needed as a tool for early detection of certain diseases according to the health problems of pregnant women in Indonesia.

Technology in the form of tools or devices
Studies found 10 health technology in the form of tools or devices, which are used to detect abnormalities or high risks in pregnant women and foetuses. Electrohysterographic is used to perform automatic detection of uterine contractions (without human intervention or through tocographic signals, TOCO) by processing electrohysterographic signals (EHG) recorded in the stomach of pregnant women (Muszynski et al., 2018). Thus, EHG is suitable for monitoring uterine contractions. This is certainly very useful because it facilitates pregnancy monitoring by a doctor or nurse.

Some abnormalities or high risks of sexually transmitted infections in pregnant women can also be assessed using the GeneXpert. Badman et al., (2016) developed a GeneXpert device with four modules to study four types of sexually transmitted infections, namely Chlamydia trachomatis (CT), Neisseria gonorrhoeae (NG), Trichomonas vaginalis (TV) and Bacterial vaginosis (BV) in pregnant women. This tool makes it easier for health care providers to do screening and also practical for pregnant women. Of course, the availability of adequate devices can optimize testing strategies as well as integrated care of sexually transmitted infections in pregnant women.

In addition to detecting diseases, various tools were also developed to detect abnormalities in the foetus. Scanning ultrasound is a tool for detecting abnormalities in the foetus, which is recommended to be done before 19 weeks' gestation. According to Getz et al. (2018), ultrasound scanning is used in high-risk and low-risk pregnancies. In addition to detecting abnormalities in the foetus, ultrasound is also used to investigate whether assisted reproductive technology (ART) increases the risk of foetal chromosomal abnormalities. The results showed that ART did not increase the risk of foetal chromosomal abnormalities (Gong et al., 2015). Furthermore, Griffiths et al. (2019) investigated the integrated in utero MR (iuMR) which is effective for assessing structural structural normality and calculating intracranial volume in foetuses with congenital heart diseases (CHD), as well as assessing the prevalence of brain abnormalities in high risk groups and comparing brain volume with normative values. With the existence of various technological tools, abnormalities in the foetus can be detected early, so as to reduce the rate of disability or death of the foetus.

Technology in the form of a tool can also assess the effect of foetal sex relations on variability in foetal heart rate using computerized cardiotocography. The male foetus shows a much lower initial foetal heart rate and greater variability than the female foetus (Bhide & Acharya, 2018). There is a significant relationship between foetal heart rate and variability with gender. Thus, computerized cardiotocography can be used to detect the sex of the foetus through the variability of the foetal heart rate, but certainly also confirmed by examination using ultrasound.

Technology can also be used to detect the possibility of premature labor. Acharya et al., (2017) developed a new algorithm using empirical mode decomposition (EMD) combined with wavelet packet decomposition (WPD), to automatically predict pregnant women if they experience premature labor, using uterine EMG signals. The results of the study show that. uterine electromyogram (EMG) or electro hysterogram (EHG) has a high sensitivity in detecting signs of preterm labor. However, visual observation and manual interpretation of EHG signals during an emergency can cause errors. Therefore a computer-assisted approach is needed to improve the prediction and characterization of women who are at risk for preterm or

normal labor using uterine EMG signals. On the other hand, Payne, S et al., (2016) developed PlexPCR technology to be able to detect vaginal colonization by various microbes and the relationship with premature labor. The disadvantage is the inability to distinguish several genotypes in the same sample. PlexPCR is far superior to the high-resolution melt (HRM) test, in revealing the number and identity of sample genotypes that were previously classified as mixed. Based on the results of the review, the two tools have different ways of working, namely to detect premature labor through visual observation and detecting microbes that have to do with preterm labor. However, both still have weaknesses in detecting, so further research is needed to improve the optimization of each tool.

Antenatal care is important to monitor mother and baby by doing regular check monthly (Widiasih, Ermi, & Setyawati, 2018). Furthermore, to improve antenatal care, Pflugeisen et al., (2016) developed a new model or program of antenatal care, namely a virtual visit for low-risk pregnant women who interspersed doctor visits directly with nurse practitioner visits through video conferencing. This program may be very relevant to the practice of serving pregnant women in the countryside or pregnant women who live far from their providers. The development and sophistication of technology, offers a variety of practical benefits in overcoming various health problems, including virtual visits. However, sometimes the problem in developing countries is that there is no even distribution of internet networks in all regions, so that the implementation of various programs has not been optimal. In addition, the mHealth system innovation for antenatal care, especially for underserved pregnant women, was found. The Pregnancy and Newborn Diagnostic Assessment (PANDA) application via smartphone, can improve health care providers' adherence to antenatal care and facilitate women's involvement in health education (Borsari et al., 2018). This is certainly very useful in antenatal care, because through this application, women are always reminded to make antenatal visits, so that problems or abnormalities during pregnancy can be detected early, and the

handling is also faster.

Conclusion

Questionnaires and tools or devices in this review can be used to detect abnormalities or diseases in risky pregnancies, however it only able to be apply by sources with special education which is health professional, and only one medical devices targeted pregnant or lactating women. High-risk pregnancies were the main background of developing health technology from various studies, however the high-risk pregnancies cases in Indonesian were differed with those studies. The existing technology makes pregnant and post partum women at high risk depending on the observation of maternal and foetal health to health workers, but in fact pregnant and post-partum women only meet with professionals once a week, and most of them are at home. Health monitoring of pregnant women cannot be separated from the fetus, because maternal health conditions will affect the fetus's health. Very few medical devices that aim to monitor the health of the fetus in pregnant women with high risk that can be used by pregnant women independently. It is necessary to develop a fetal health monitoring device specifically for high-risk pregnant women which easy to operate by mother and family at home. The tool will help mother and family in monitoring foetus, do risks of health problems will be detected by the mother and fetus immediately, then mother would visit the nearest health service for help.

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