Journal of Infection and Public Health 12 (2019) 608–614

Contents lists available at ScienceDirect

Journal of Infection and Public Health

journal homepage: http://www.elsevier.com/locate/jiph

National screening programs in Saudi Arabia: Overview, outcomes, and effectiveness

Ibrahim M. Gosadi

Department of Family and Community Medicine, Faculty of Medicine, Jazan University, P.O. Box: 2349, Jazan, 82621, Saudi Arabia

ARTICLE INFO

Article history:
Received 5 April 2019
Received in revised form 27 May 2019
Accepted 9 June 2019

Keywords:
Saudi
Screening
Premarital
Newborn
Cancer

ABSTRACT

In 2016, the government of Saudi Arabia launched the National Transformation Program to ensure the realisation of Kingdom's Vision 2030. One of the strategic objectives is Health Promotion against Health Risks (Public Health System and Health Disasters Management). The new Institutional Transformation and Health Care Model involves actions focusing on diseases prevention and strengthening the primary health care system. Success of the new Health Care Model in Saudi Arabia is only possible when considering assessment of factors influencing national prevalence of health risk factors and early detection of chronic diseases. This notion mandates availability of national screening programs that are able to identify individuals at risk or asymptomatically suffering from chronic diseases. This review is aiming to provide an overall overview of current governmental national screening programs in Saudi Arabia, to assess utilisation and outcomes of screening services in Saudi Arabia and assessment of effectiveness of current national screening programs.

Contents

E-mail addresses: gossady@hotmail.com, igosadi@jazanu.edu.sa

https://doi.org/10.1016/j.jiph.2019.06.001

Introduction

Screening is a means of prevention of diseases, which aims to detect asymptomatic patients at an early stage of the disease. In 1986, Wilson and Jungner established criteria used to assess the appropriateness of screening. These criteria were related to the importance of health problems, and availability and acceptability of the screening test, availability of adequate health services for confirmation of diagnosis and treatment of subjects and, finally, the benefits of screening should outweigh risks. With advancement of screening tools, especially with regards to genetic testing, these criteria have been revisited by Andermann et al. to suggest more specific criteria, such as provision of evidence of effectiveness of screening programs, integration of education, testing, clinical services and ensuring equity and access to screening for the targeted population [1].

Prevalence of diseases and risk factors vary between populations and countries. Initiation of nationwide screening programs can be justified by prevalence of diseases and associated social and economic burden, and availability of a competent health system ensuring effective application of the screening programs. However, inability to identify and invite targeted population, limited participation of targeted subjects, and lack of infrastructures to diagnosis and treat detected cases will eventually limit the effectiveness of any screening program [2].

According to the Saudi Ministry of Health (MOH), 75% of the Saudi population do not perform routine check-ups, 60% are either overweight or obese, 60% do not engage in sufficient physical activities and 18% of Saudis are smokers. Additionally, 46% of deaths related to non-communicable diseases occur in younger individuals in comparison to western European populations. With the current prevalence of health risk determinants, the number of Saudis with chronic diseases is expected to increase from 5 million to 10 million by 2030 [3].

In 2016, the government of Saudi Arabia launched the National Transformation Program to ensure the realisation of Kingdom's Vision 2030. The program involved 24 governmental agencies to establish achievement of 96 strategic objectives of Vision 2030. One of the strategic objectives is Health Promotion against Health Risks (Public Health System and Health Disasters Management) [4]. The new Institutional Transformation and Health Care Model, which is led by the Saudi Ministry of Health, involves actions focusing on diseases prevention and strengthening the primary health care system [3].

Diseases prevention can be established at primary, secondary or tertiary levels. It is possible to argue that success of the new Health Care Model in Saudi Arabia is only possible when considering assessment of factors influencing national prevalence of health risk factors and early detection of chronic diseases in the country. This notion mandates availability of national screening programs that are able to identify individuals at risk or asymptomatically suffering from chronic diseases.

Review scope

This review is aiming to provide an overall overview of current governmental national screening programs in Saudi Arabia. Additionally, this review is aiming to provide a summary of available evidence concerning utilisation and outcomes of screening services in Saudi Arabia and factors influencing utilisation. A description of screening efforts for prevalent diseases in the country with currently no available national screening program is also reported. A brief comparison to other screening programs established in other countries is made. Finally, assessment of effectiveness of national screening programs in Saudi Arabia is briefed.

Overview of national screening programs in Saudi Arabia

Currently, there are two national screening programs conveyed mainly by the Saudi Ministry of Health in addition to other governmental health facilities, namely, the premarital screening program, and the National newborn screening program. Both programs are established all over the kingdom with clear descriptions concerning targeted subjects, locations of performing screening tests and the process of screening. It can be noted that both programs are mainly screening for genetic disorders in a manner either aiming to detect couples who are carriers or affected before their marriage or detecting affected newborns at early stages.

Premarital screening program

The Premarital screening program (currently called Healthy Marriage Program) was initiated in 2004 and involves screening individuals intending to get married, for sickle cell disease, thalassemia, HIV, and hepatitis B and C. This screening is mandatory for any couples planning to get married in Saudi Arabia. After completion of screening, couples are issued a certificate of premarital screening enabling them to proceed for marriage.

Premarital screening program is currently performed in 131 centers in MOH hospitals, and aims to reduce the numbers of marriage between couples who are at risk of having children affected with sickle cell disease, thalassemia, HIV, or hepatitis B or C. Screened couples who are found to be affected or carriers of these conditions and are likely to have affected children are labelled as "risky couples". According to the current procedures following detecting subjects affected or carriers of these conditions, marriage of risky couples is not prevented, and they are only referred to consultation clinics for further evaluation and advice [5].

According to the Saudi Ministry of Health's available guidance concerning premarital screening, couples who are labelled as risky couples, likely to have children affected with sickle cell anaemia or thalassemia and insist on proceeding with the marriage are educated about risk and the health complications experienced among affected children. However, if one of a screened couple were found to be affected with hepatitis B or C or HIV, the other spouse-to-be would be informed about the infection, and then requested to revisit the decision to proceed with marriage. Furthermore, if a spouse-to-be were found to be affected with hepatitis B and the couple insisted on proceeding with the marriage, the healthy spouse-to-be would be transferred to a preventive medicine clinic for further evaluation and vaccination with hepatitis B vaccine. Nonetheless, the current practice guidance concerning detecting a partner affected with hepatitis C or HIV is not clear and the recommended guidance is referral to a preventive medicine clinic at the hospital for further consideration [6].

Table 1
List of inborn errors of metabolism and endocrine disorders screened for within the National Newborn Screening Program in Saudi Arabia [7].

Aminoacidopathies	Phenylketonuria (PKU) Argininosuccinatelyase deficiency (ASL) Maple syrup urine disease (MSUD) Citrullinaemia
Organic acid disorders	Propionic acidaemia (PPA), Methylmalonicacidaemia, Glutaricacidaemia type-I Isovalericacidaemia 3-methylcrotonyl-CoA carboxylase deficiency (3-MCC)
Fatty acid oxidation defect	Medium-chain acyl CoA dehydrogenase deficiency
Ketogenesis and ketolysis defects	3-hydroxy-3-methylglutaryl-CoA lyase deficiency Beta-ketothiolase deficiency (BKT)
Carbohydrate disorder	Galactosaemia (GALT)
Endocrine disorders	Congenital hypothyroidism (CH) Congenital adrenal hyperplasia (CAH)
Vitamin responsive disorder	Biotinidase deficiency.

National newborn screening program

In 2005, the National newborn screening program was initiated in Saudi Arabia, aiming to screen for inborn error of metabolism and endocrine disorders [7]. According to the Saudi Ministry of Health, the program aims to screen all newborns within 24–72 h of delivery, and is currently performed in 183 hospitals all over the kingdom [8]. Upon its establishment, 16 inborn errors of metabolism and endocrine disorders are screened for which are summarized in Table 1 [7]. In 2016, screening for hearing-loss and critical congenital heart defects was added to newborn screening, which is currently performed in 30 referral Ministry of Health hospitals [6].

At the time of writing this review, governmental guidance concerning procedures of newborn screening in Saudi Arabia was lacking. Nonetheless, the study by Alfadhel et al. described the historic background of the Saudi newborn screening program and procedures concerning screening tests of newborns [7]. According to Alfadhel et al. the Saudi Ministry of Health formed a National Newborn Screening Committee, which was responsible for overseeing, planning, monitoring and evaluation of the program. Additionally, the committee was responsible for selection of diseases to be screened for where selection was justified by frequency of newborn illnesses in the Saudi population, accessibility and availability of confirmatory tests and treatments. The study by Alfadhel et al. highlighted the workflow of the Saudi newborn screening program, including procedures concerning repeat of screening tests for initially positive results, confirmation using biochemical testing and referral system to specialised hospitals for management plan initiation.

Outcomes and current trends of screening in Saudi Arabia

Premarital screening program

One of the earliest publications concerning the epidemiological situation of hemoglobinopathies in Saudi Arabia was the review by El-Hazmi, published in 2004. In this review, it was described how endemicity of malaria aided in increasing prevalence of hemoglobinopathies, such as sickle cell disease and thalassemia in certain regions in the country. With the advancement of transportation systems, movement of Saudi citizens to other regions in the country facilitated spread of these blood disorders all over the kingdom, mandating establishment of a national screening program for hemoglobinopathies, which later included other infectious diseases screened for the premarital screening [9].

The national premarital screening program provided an opportunity for researchers to study the national prevalence and distribution of hemoglobinopathies in the country. Table 2 summarises studies reporting outcomes concerning prevalence of hemoglobinopathies. In 2007, Alhamdan et al. published one of the earliest findings of the Premarital screening program for the period between 2004 and 2005. At the beginning of the program, it was clearly apparent that counselling had limited benefit in reducing marriage of risky couples, where about 90% of risky couples proceeded with their marriage despite informing them about the probability of having offspring affected with hemoglobinopathies [10]. Similarly, in 2010, Al Sulaiman et al. reported their findings of following up a limited sample of 129 couples who were identified by the premarital screening program as risky couples, where 98% proceeded with their marriage despite the risk. Al Sulaiman et al. investigated factors influencing decisions to proceed with marriage despite informing them about the risks of having affected children, and cultural pressure was on one of the main reasons behind rejecting the counselling advice [11].

In 2011, Memish and Saeedi [12] reported their findings of outcomes of premarital screening covering a longer period between 2004 and 2009, where a marked reduction in overall prevalence of thalaseemia traits is observed when compared to the study of Alhamdan et al. [10]. Additionally, there was a reduction in the number of couples identified as risky and who had decided to proceed with marriage by the end of 2009. This reduction implies the presence of a positive impact on increasing awareness of the population concerning health consequences of having children affected with hemoglobinopathies which can be considered as an evidence of success of the premarital screening program. Finally, the latest publication concerning outcome of the screening program was published by Alsaeed et al. in 2018, where overall prevalence of hemoglobinopathies are similar to previous trends. Nonetheless, the study by Alsaeed et al. did not report the proportion of identified risky couples and no follow- up was made, which indicates an area of future research to investigate the current trend in cancellation of risky marriage proposals after 16 years of implementing the premarital screening program [13].

Studies assessing outcomes of premarital screening program with regards to infectious diseases are limited. A study by Alswaidi and O'Brien reviewed a sample of 74,662 individuals within the premarital screening program between January and May 2008. Reported prevalence of HIV was 0.03%, 1.31% for HBV and 0.33% for HCV. A sample of 270 individuals detected with HIV, HBV or HVC were followed up to assess outcome of premarital counseling where 224 affected individuals reported that their spouse- to-be were free of infectious diseases and about 172 (77%) decided to proceed with marriage [14]. Another study by Abdullah assessed prevalence of Hepatitis B and C virus infections among subjects undergoing premarital screening between January 2014 and June 2015 with a total of 7826 screened individuals in a single center in Jazan region, south of Saudi Arabia. The prevalence of Hepatitis B virus infection was 1.66% and was 0.2% for hepatitis C infection [15]. Nonetheless, this investigation did not provide any report for follow up of risky couples' decision to marry.

National newborn screening program

Several independent and localized investigations were conducted in Saudi Arabia as screening efforts for selected newborn programs. Three studies were found where screening for congenital anomalies and inborn error of metabolism was performed for newborns between 1980 and 1999 [16–18]. The findings of these investigations recommended establishment of a Saudi newborn screening program. An early literature review by Afifi and Abdul-Jabbar published two years after the establishment of the Saudi

Table 2
Outcomes of Premarital Screening Program in Saudi Arabia.

References	Period	Number of screened subjects	Sickle cell trait	Sickle cell disease	Thalassemia trait	Thalassemia disease	Risky couples identified and decision to marry
[10]	2004–2005	488,315	4.2%	0.26%	3.22%	0.07%	4437 couples (2.14%) 89.6% of risky couples proceeded with marriage
[12]	2004–2009	1,572,140	4.2%	0.27%	1.79%	0.04%	8925 couples (1.13%), 5370 couples were followed up where 73% of risky couples proceeded with marriage
[13]	2011–2015	1,230,582	4.5%	0.37%	1.24%	0.06%	Not reported

Newborn Screening Program and assessed needs and challenges of the program. In their review, Afifi and Abdul-Jabbar justified the need for newborn screening program by the high birth rate of Saudi population and higher incidence of newborn disorders in comparison to US and Japanese populations where approximately 500 cases could be detected on yearly basis. However, they highlighted several challenges that might face the program especially the health care service infrastructure including interconnections of different level of health sectors, geographic limitations aiding to lack of experts able to manage rare diseases in different regions in the Kingdome [19].

A single comprehensive retrospective study by Alfadhel et al. reported findings of 775,000 newborns screening in Saudi Arabia covering the period between 2005 and 2012 performed in 139 hospitals [7]. A total of 743 cases were detected where most frequently reported cases were congenital hypothyroidism, congenital adrenal hyperplasia and propionic acidaemia. According to Alfadhel et al. the incidence of newborn errors is one of the highest in the globe and this high incidence can be justified by the high rate of consanguineous marriages in Saudi Arabia. In addition to the high rate of consanguinity, Alfadhel et al. indicated the importance of provision of infrastructures, training, and public awareness to ensure continuity and success of the program which is similar to the notion made by Afifi and Abdul-Jabbar et al. in their review.

Screening for common illnesses in Saudi Arabia

In addition to hemoglobinopathies, infectious diseases and newborn condition, there are several conditions which are prevalent in Saudi Arabia. These conditions involve different types of cancers and several metabolic illnesses. Nonetheless, national screening programs for these diseases are either not yet established or not properly implemented. In this section, we provide a description of prevalent disease in Saudi Arabia and available evidence concerning screening efforts made.

According to the Saudi Cancer Registry, most common types of cancers reported in 2014 in Saudi Arabia are breast cancer, colorectal cancer, thyroid cancer, Non-Hodgking lymphoma and leukemia. The total number of diagnosed cancer cases in Saudi Arabia in 2014 among females was 6264 where most common type of cancers reported among females was breast cancer (28.7%). Additionally, in the same year, 5299 cancer cases were diagnosed among Saudi males where most common type of cancer was colorectal cancer (14.2%) [20].

In 2013, Saudi Ministry of Health published the findings of the Saudi Health Interview Survey. This was a house-hold survey covering all administrative regions in the kingdom involving a sample of 10,827 where data concerning blood cholesterol, blood glucose, blood pressure and lifestyle of Saudis aged between 15 and 65+ were collected. According to the survey, prevalence of pre-hypertension, pre-hypercholestrolemia, and pre-diabetes were 40.5%, 20%, and 16.3% respectively among all age groups where prevalence was reported to increase among older Saudis [21].

Screening for breast cancer

In 2007, the first nationwide breast cancer screening center was established via non-governmental collaboration between Abdul Lateef Charitable Screening Center and the Saudi Cancer Society and was based in Riyadh city. Abulkhair et al. published their findings of a retrospective review of 1215 women who were screened in this center between September 2007 and April 2008. Using mammogram to screen for breast cancer, out of 1215, only 16 cases were detected [22]. Another non-governmental screening program was initiated in Eastern province in Saudi Arabia using mobile mammogram machines where 8061 women were screened between 2009 and 2014 and only 47 cases were detected [23]. First published report concerning governmental breast screening program was concerning a pilot study of breast screening program in Alqassim region in center of Saudi Arabia [24]. Nonetheless a clear description of a nationwide screening program for breast cancer is currently limited.

A national campaign to raise awareness about early screening for breast cancer was initiated by the Saudi MOH in 2015 as a promotion for the National Program for Early detection for Breast Cancer [25]. However, the process of seeking screening for breast cancer is not clear, and at the time of writing this review, was not available in the official website of Saudi Ministry of Health. A paper titled “Breast cancer screening in Saudi Arabia: free but almost no takers” by El Bcheraoui et al. was based on finding of Saudi Health Interview Survey and investigated utilization of women for breast cancer screening services. El Bcheraoui et al. reported that among 1135 women who were aged 50 and older, 92% of them reported never having a mammogram [26]. The low participation rate can be partially explained by extreme lack of information concerning available screening services for breast cancer.

Screening for colorectal cancer

Although colorectal cancer is most common type of cancer among Saudi men, currently, there is no nationwide screening program for colorectal cancer in Saudi Arabia. According to the Saudi MOH, only 9% of colorectal cancer cases are diagnosed at early stages of colorectal cancer [27]. According to Mosli and Al-Ahwal, there is a trending increase incidence of colorectal cancer in Saudi Arabia where this increase justifies a nationwide screening approach for colorectal cancer [28]. In 2015, the Saudi Centre for Evidence-Based Healthcare assembled a panel of experts for development of National Guidelines for Colorectal Cancer Screening in Saudi Arabia where the panel recommended establishment of a colorectal screening program targeting asymptomatic patients at average risk of the disease [29].

Table 3
Examples of different national screening programs established in European, American, Asian and Western Pacific countries in addition to current screening programs in Saudi Arabia.

United Kingdom [34]	Netherland [35]
1. Abdominal aortic aneurysm	1. Breast cancer screening
2. Bowel cancer screening	2. Cervical cancer screening
3. Breast screening	3. Bowel cancer screening
4. Cervical screening	4. Antenatal screening for infectious diseases and erythrocyte sensitisation
5. Diabetic eye screening	5. Screening for Down's, Edwards' and Patau's syndromes in pregnancy
6. Fetal anomaly screening	6. Structural ultrasound scan
7. Infectious diseases in pregnancy screening	7. Neonatal blood spot screening
8. Newborn and infant physical examination	8. Neonatal hearing screening
9. Newborn blood spot screening programme	
10. Newborn hearing screening	
11. Sickle cell and thalassaemia (SCT) screening	
New Zealand [36]	United States [37,38]
1. National Bowel Screening Programme	1. Newborn screening.
2. Breast Screen Aotearoa (Brease cancer screening)	2. National Breast and Cervical Cancer Early Detection Program (NBCCEDP)
3. National Cervical Screening Programme	
4. Newborn Metabolic Screening Programme	
5. Universal Newborn Hearing Screening Programme	
Australia [39]	Singapore (mass screening programs) [40]
1. The National Breast Screening program	1. Obesity
2. The National Cervical Screening Program	2. Hypertension.
3. The National Bowel Cancer Screening Program	3. Diabetes mellitus.
4. Newborn Bloodspot Screening	4. Hyperlibidemia.
5. Newborn Hearing Screening	5. Colorectal cancer.
	6. Cervical cancer.
	7. Breast cancer.
	8. Newborn screening.
Saudi Arabia	
1. Premarital Screening Program	
2. National Newborn Screening Program	

Despite lack of a nationwide program for colorectal cancer screening, the Saudi MOH does promote for the importance of screening for the disease [27]. However, awareness raising efforts about colorectal cancer screening can be described as modest in comparison to breast cancer. In 2018, Khoja et al. published their findings regarding utilization of colorectal screening services in the country based on a sample of 2946 selected from The Saudi National Survey for Elderly Health. In their sample, utilization of colorectal cancer screening was 5.64% where less than 1% utilized colonscopy [30].

Screening for diabetes, hypertension and hypercholesterolemia

According to the World Health Organization, non-communicable disease accounts for 73% of mortality of Saudis where more than one third of mortalities are attributed to cardiovascular diseases [31]. Obesity, raised blood pressure, and diabetes are main risk factors for development of cardiovascular diseases among Saudis. Despite increased prevalence and high health and economic burden, screening policy for these risk factors among Saudis is currently not available and only public awareness days are organized on yearly basis [32].

In the Saudi Health Interview Survey which included a sample of 10,827 Saudis, 1089 participants were reported as undiagnosed cases of hypertension. Similarly, 389 participants were detected as undiagnosed diabetes cases, and 360 participants were found to have undiagnosed hypercholesterolemia [21]. In addition to the prevalence of individuals who have borderline levels of blood glucose, cholesterol and blood pressure, about half of undiagnosed Saudis with these conditions were younger than 44. The current prevalence of borderline subjects and undiagnosed young patients indicates the importance of early detection of such cases in Saudi Arabia via establishment of an organized screening program.

In 2008, the Saudi MOH launched a small scale community-based interventional program called (The Crown Health Project) in Al-Jouf region. This small region located north of Saudi Arabia was selected to test the feasibility and effectiveness of the program with the final aim of generalizing the program to the rest of the country. The project was focusing on prevention of non-communicable diseases via several steps including screening for risk factors related to lifestyle, medical history, and physical and biochemical measurements. According to Memish et al. the interest of key leaders in Al-Jouf region enhanced the feasibility of the project and, therefore, it is highly important to involve key community leaders in the progress of community-based projects [33].

International screening programs

In this section, we aim to provide examples of different national screening programs established in European, American, Asian and Western Pacific countries. Table 3 illustrates screening programs established in United Kingdom, Netherland, New Zealand, United States, Singapore and Australia in addition to Saudi Arabia. All listed international countries have established screening programs for newborns, screening for breast cancer and screening for cervical cancer. Among these countries, antenatal screening programs are only offered in United Kingdom and Netherland. Additionally, mass screening for obesity, hypertension, diabetes mellitus and hypercholesterolemia is only offered in Singapore.

Although some of countries listed in Table 3 have established sickle cell and thalassemia, and infectious diseases screening during pregnancy, none has a national premarital screening program resembling the current premarital screening program in Saudi Arabia. This stems from the uniqueness of Saudi culture where mating of couples and having children without marriage is prohibited. This is an example of how cultures of communities influence provision of health services where this cultural principle in Saudi Arabia facilitated application of the screening program in a mandatory manner which is very unlikely to be applied as a mass screening strategy in remaining countries listed in Table 3. Similarly, cul-

tural believes prohibiting termination of pregnancy in Saudi Arabia explains absence of antenatal screening programs.

Effectiveness of national Saudi screening programs

Several elements can be utilised to evaluate a screening program, such as feasibility, access and cost of screening programs. However, a main component of evaluation is measuring the effectiveness of a screening program in terms of observing how screening modifies subsequent outcomes of the diseases of interest in screened communities. This review was able to detect several aspects of currently established screening programs requiring further research and actions.

The effectiveness of premarital screening is evident by reduction of proportions of risky couples who proceeded with marriage from about 90% by the end of 2005 to 73% by end of 2009 as illustrated in Table 2. Additionally, by inspecting the reduction of proportion of identified risky couples from 2.14% by the end of 2005 to 1.13% by the end of 2009, it is possible to argue that the presence of public health awareness concerning hereditary and infectious diseases had led to reduction of marriage proposals of couples who are known to carry or are affected by hereditary or infectious diseases. The proportion of marriages of risky couples is expected to decline after 16 years of establishment of the program due expected increased public awareness of hereditary and infectious diseases.

Establishment of counseling clinics is an important contributor in this reduction aiding in increased awareness of risky couples and enabling making an informed-decision. Furthermore, targeting cultural and traditional beliefs in the Saudi community encouraging marriage of risky couples, especially those who are related, may require interference of officials, religious and tribal leaders in the country. Targeting specific social and cultural factors influencing risky couples' decision to proceed with marriage despite counseling is an area of further research.

In addition to effectiveness, feasibility and access to the national screening program in Saudi Arabia are markedly influenced by the availability of information about established programs. In this review, we found difficulties in finding information related to the availability of screening tests for breast cancer and colon cancer, and this may explain the low utilisation of screening services described in this review. Additionally, a list of newborn conditions currently screened for Saudi Arabia is not available via governmental portals to Arabic-speaking citizens, and are only available for the scientific community as published literature in the English language. Finally, in a country with one of the highest prevalence of metabolic diseases in the globe, enhanced utilisation of the currently available infrastructures for early diagnosis, and treatment can only be achieved via establishing a national screening policy capable of encouraging Saudis to screen for these conditions as early as possible.

Funding

No funding Sources.

Competing interests

None declared.

Ethical approval

Not required.

Acknowledgments

None.

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