HIGHLIGHTS

R&D PROJECTS AND PROGRAMS | R&D COLLABORATIONS AND PARTNERSHIPS | R&D OUTPUTS AND OUTCOMES

THE RESEARCHER

KAIMRC NEWSLETTER

ISSUE FOUR
APRIL 2017

innovations.kaimrc.med.sa/en/newsletters

From oil to biomedical research

Growing the healthcare sector by investing in education and research training for Saudis.

In April 2016, the Saudi Arabian government, under the leadership of King Salman bin Abdulaziz Al Saud, released Saudi Vision 2030, a diversification blueprint to boost non-oil-based revenues; tapping into other natural resources such as gold, copper, uranium and aluminium; enhancing the role and contributions of small- and medium-sized enterprises; and increasing dependence on and investment in renewable energy sources, among others.

The kingdom seems well on its way to an economic transformation, now ranking 29 on the Global Competitiveness Index 2016/2017, which looks at the drivers of different economies' productivity and prosperity. It also ranks third among all the countries of the Arab world (see graph on page 8).

In the areas of health and higher education, training, technological readiness, and innovation King Abdullah International Medical Research Center (KAIMRC), the research institute of the Ministry of National Guard-Health Affairs (MNG-HA), steps in.

"The main aim [of Saudi Vision 2030] is encapsulated by KAIMRC's strategy and activities," explained Ahmed Alaskar, KAIMRC's executive director.

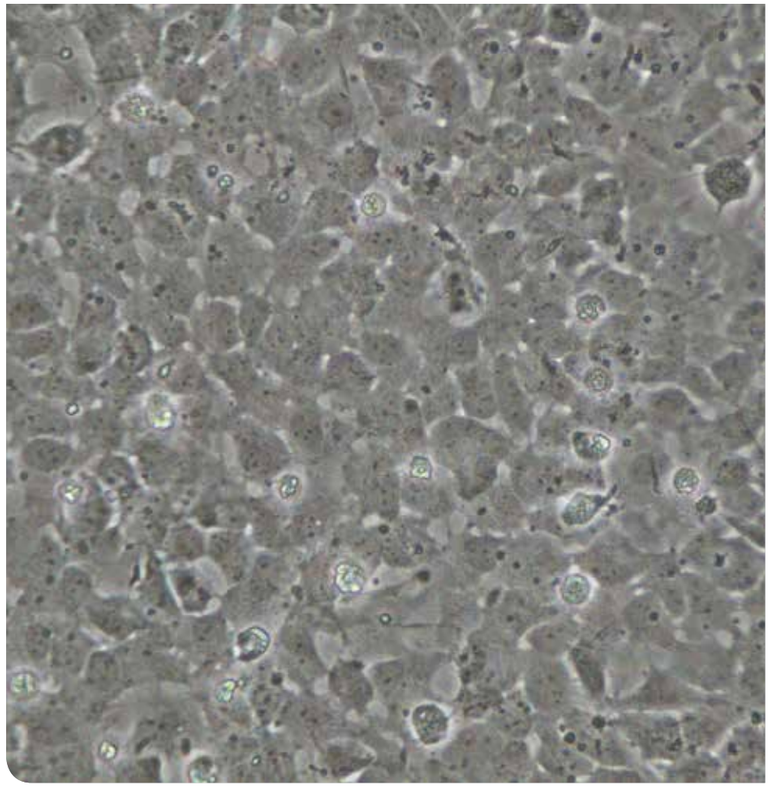
MNG-HA's strategy focuses on investing in education and training to support the ambitions and potential of Saudis. "It is also to sustainably invest in people's minds by conducting medical and innovative research guided by a strategy to have a positive impact on people's health and on the national economy," adds Alaskar.

KAIMRC's executives point to it as a source of knowledge and a centre of collaboration with science researchers around the world.

"KAIMRC is keen on adopting new, creative and innovative research that will achieve a paradigm shift in healthcare services," said Bandar AlKnawy, chief executive officer of MNG-HA and president of King Saud University of Health Sciences. "In this way, we are developing the healthcare sector and the knowledge economy."

DELVING INTO THE ORIGINS OF INHERITED DISEASES

KAIMRC is making a splash in the understanding of genetic disorders that impact the immune system thanks to Abbas Hawwari, a senior research scientist at KAIMRC and King Saud bin Abdulaziz University for Health Sciences.



JOSEPH ESSEBENDI/CC BY 2.0

Hawwari has devoted his career to elucidate the genetic causes of primary immunodeficiencies in Saudi Arabia, where they are more prevalent than in the rest of the world due to high consanguinity rates. While helping physicians diagnose immunodeficiency diseases, he intends to speed up diagnosis and treatment in affected children and facilitate premarital screening for couples from families with a history of these diseases.

After a Master of Science in immunology and infectious diseases at John Hopkins University in the US, the microbiologist earned a doctoral degree in molecular immunology from the University of Adelaide in Australia. He honed his expertise in this field at Duke University Medical Center before joining the King Faisal Specialist Hospital and Research Centre (KFSH&RC) in Riyadh as head of the transcriptional genetics and immunogenetics sections.

At KFSH&RC, Hawwari's team discovered and characterized novel genetic defects that are unique to Saudis with immunodeficiencies.

For the first time, the researchers also generated a panel of 264 genes involved in the development of immunodeficiency. Implementing the panel in a next-generation sequencing platform, which can decrypt an entire genome within a single run, provided a money- and time-saving screening system for immunodeficient patients. "I am proud of this work because we found many genetic defects that were undetectable by conventional methods," says Hawwari.

"Dio. Tur, ea consed ut laccus et volor aut autet es est, occupid mod molorerit, nes aut velenem quo cus modipsus rae. Itatur? Uciatia dolest, quos in repelese cons"

Moreover, the researchers devised newborn screening methods for some immunodeficiency diseases. Early disease identification is expected to facilitate a timely intervention that could save the lives of immunodeficient babies. "Very few laboratories around the world have developed such screening methods," he says.

Hawwari has now expanded his scope of research. His KAIMRC team is investigating a transcription factor called RORgammaT, whose absence affects the development of the immune system and, consequently, promotes cancer and autoimmunity. The team is also studying the gene DOCK-8, which triggers severe allergic reaction and death when mutated. The team hope to identify and create diagnostic tools for the condition along with alternatives to bone marrow transplantation, which is currently the only treatment for the mutation-induced disease.

According to Hawwari, methodologies used to evaluate inherited defects are applicable to other high-priority areas for KAIMRC, such as cardiovascular and endocrine disorders as well as cancer. "Studying the underlying genetic defects of these diseases is of primary importance to KAIMRC," he adds.

BOOSTING ANTI-CANCER DRUG EFFICACY WITH A SHIELD

A nanotechnology-based capsule filed with the US patent office could enhance the delivery of anti-cancer drugs to their target.

Biomolecular scientist Majed Halwani and his colleague Moayad Alhariri have devised a delivery system using nano-sized pockets for doxorubicin, a potent anti-cancer drug with severe cardiovascular side-effects. "This system enhances doxorubicin's activity and reduces its adverse side effects," says Halwani.

In most nanoparticle formulations, a shell encloses the drug and protects it from the host environment until the target site is reached. These formulations partly enhance drug activity but their efficacy only depends on the drug molecule. "Our formulation itself has therapeutic capabilities because it also comprises anti-oxidative omega-3 fatty acids and anti-cancer polysaccharides called glucans," explains Halwani.

The new system substantially decreased the viability of various cancer cell lines, such as lung carcinoma epithelial cells and colorectal adenocarcinoma cells, compared to free doxorubicin. This is expected to ease doxorubicin dosage requirements and, therefore, cardiovascular toxicity.

"I am very excited with these results and feel we can take this formulation to the next level," says Halwani. The researchers are planning to examine many parameters, including formulation stability and cardiovascular toxicity, before evaluating therapeutic value.

Yaseen Arabi recognized for research excellence

Dr. Yaseen Arabi is the winner of this year's distinguished scientist category of the Almarai Prize for Scientific Innovation.

The annual prize, awarded by Saudi food and drink company Almarai in partnership with King Abdulaziz City for Science and Technology, aims to support innovation in the kingdom.

Arabi is chair of intensive care and medical director of respiratory services at King Abdulaziz Medical City in Riyadh. He is also an associate professor at King Saud Bin Abdulaziz University and a fellow of the American College of Critical Care Medicine and the American College of Chest Physicians. He has published more than 140 research papers.

Arabi is American Board-qualified in three medical branches he sees as being clinically interrelated: internal medicine, pulmonary diseases and critical care. "This helps in working on cases where there is an overlap, such as in Middle East respiratory syndrome (MERS)," he says.

Arabi has contributed to several studies exploring potential treatments for MERS CoV, the coronavirus implicated with the syndrome. One of these studies explored the efficacy of antibodies in the plasma of recovered MERS patients for treating others diagnosed with the disease.

Arabi is currently investigating the potential of treating MERS patients by using a drug combination commonly used in the treatment of HIV/AIDS, together with an interferon used to treat multiple sclerosis.

This award is not Arabi's first. In 2011, he received the Barry A. Shapiro Memorial Award for Excellence in Critical Care Management from the Society of Critical Care Medicine. He was also the recipient of the 2008 Humanitarian Project Development Grant from the CHEST Foundation, the charitable foundation of the American College of Chest Physicians.

666 **Provisional number** of 2016 publications **17585** Total number of citations (from Dr Kelya)

TEN HIGHEST IMPACT FACTOR ARTICLES FROM KAIMRC

[1]Bellani G, [2] Laffey JG, [3]Pham T, [4]Fan E, ... [5]Arabi, YM, et al.	[1]School of Medicine and Surgery, University of Milan-Bicocca and Department of Emergency and Intensive Care, San Gerardo Hospital, Monza, Italy; [2]Departments of Anesthesia, Physiology and Interdepartmental division of Critical Care Medicine, University of Toronto, Canada; [3]AP-HP, Hôpital Tenon, Unité de Réanimation médico-chirurgicale, Pôle Thorax Voies aériennes, Groupe hospitalier des Hôpitaux Universitaires de l'Est Parisien, Paris, France; [4]Department of Medicine, University Health Network and Mount Sinai Hospital; ... [5]**Department of Intensive Care, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia; et al.**	EPIDEMIOLOGY, PATTERNS OF CARE, AND MORTALITY FOR PATIENTS WITH ACUTE RESPIRATORY DISTRESS SYNDROME IN INTENSIVE CARE UNITS IN 50 COUNTRIES.	JAMA	35.289
[1]Faisal A, [2]Alghamdi BJ, [3]Ciavaglia CE, [4]Elbehairy AF, [5]Webb KA et al.	[1-5]Respiratory Investigation Unit, Department of Medicine, Queen's University and Kingston General Hospital, Kingston, Ontario, Canada; [2]**King Saud Bin Abdulaziz University for Health Science, King Abdullah International Medical Research Center, Jeddah, Saudi Arabia**; et al.	COMMON MECHANISMS OF DYSPNEA IN CHRONIC INTERSTITIAL AND OBSTRUCTIVE LUNG DISORDERS.	AMERICAN JOURNAL OF RESPIRATORY CRITICAL CARE MEDICINE	12.996
[1]Mokdad AH, [2]Forouzanfar MH, [3]Daoud F, [4]Mokdad AA,... [5]AlBuhairan F, et al.	[1]Institute for Health Metrics and Evaluation, University of Washington, Seattle, USA. [2-4]Institute for Health Metrics and Evaluation, University of Washington, Seattle, USA; [5]**King Abdullah Specialized Children's Hospital, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia.**	GLOBAL BURDEN OF DISEASES, INJURIES, AND RISK FACTORS FOR YOUNG PEOPLE'S HEALTH DURING 1990-2013: A SYSTEMATIC ANALYSIS FOR THE GLOBAL BURDEN OF DISEASE STUDY 2013.	LANCET	45.217
[1]Motwani M, [2]Dey D, [3]Berman DS, [4]Germano G, ... [5]Al-Mallah MH, et al.	[1-4]Departments of Imaging and Medicine and the Cedars-Sinai Heart Institute, and the Biomedical Imaging Research Institute, Department of Biomedical Sciences, Cedars-Sinai Medical Center, Los Angeles, CA, USA; [5]**King Saud bin Abdulaziz University for Health Sciences, King Abdullah International Medical Research Center, King AbdulAziz Cardiac Center, Saudi Arabia.**	MACHINE LEARNING FOR PREDICTION OF ALL-CAUSE MORTALITY IN PATIENTS WITH SUSPECTED CORONARY ARTERY DISEASE: A 5-YEAR MULTICENTRE PROSPECTIVE REGISTRY ANALYSIS.	EUROPEAN HEART JOURNAL	15.064
[1]Sifrim A, [1-3]Hitz MP, [4]Wilsdon A, [5]Breckpot J, [1,6-7]Turki SH, ... [7]Abu-Sulaiman RM, et al.	[1]Wellcome Trust Sanger Institute, Cambridge, UK; [2]Department of Congenital Heart Disease and Pediatric Cardiology, Universitätsklinikum Schleswig-Holstein Kiel, Germany; [3]German Center for Cardiovascular Research, Berlin, Germany; [4]School of Life Sciences, University of Nottingham, UK; [5]Center for Human Genetics, University Hospitals Leuven, Belgium; [6]**Department of Pathology, King Abdulaziz Medical City, Riyadh, Saudi Arabia; [7]Division of Pediatric Cardiology, King Abdulaziz Cardiac Center, King Abdulaziz Medical City, Ministry of National Guard-Health Affairs, Riyadh, Saudi Arabia, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia**; et al.	DISTINCT GENETIC ARCHITECTURES FOR SYNDROMIC AND NONSYNDROMIC CONGENITAL HEART DEFECTS IDENTIFIED BY EXOME SEQUENCING	NATURE GENETICS	31.616
[1]Tähtinen RM, [2]Cartwright R, [3]Tsui JF, [4]Aaltonen RL, ... [5]Al Juaid S, et al.	[1]Kuopio University Hospital, Kuopio, Finland, Department of Obstetrics and Gynecology, Kanta-Häme Central Hospital, Finland; [2]Department of Epidemiology and Biostatistics, Imperial College London, UK; [3]Department of Urology, North Shore-LIJ Lenox Hill Hospital, New York, NY, USA; [4]Department of Obstetrics and Gynecology, University of Turku and Turku University Hospital, Turku, Finland; [5]**Department of Obstetrics and Gynecology, King Saud bin Abdulaziz University for Health Sciences, and King Abdulaziz Medical City, Ministry of National Guard Health Affairs, Jeddah, Saudi Arabia**; et al.	LONG-TERM IMPACT OF MODE OF DELIVERY ON STRESS URINARY INCONTINENCE AND URGENCY URINARY INCONTINENCE: A SYSTEMATIC REVIEW AND META-ANALYSIS.	EUROPEAN UROLOGY	13.938
[1]Tarailo-Graovac M, [2]Shyr C, [3]Ross CJ, [4]Horvath GA, [5]Alfadhel M, et al.	[1-4]Centre for Molecular Medicine and Therapeutics, Departments of Medical Genetics, University of British Columbia, Canada; ... [5]**Division of Genetics, Department of Pediatrics, King Saud Bin Abdulaziz University for Health Sciences, King Abdulaziz Medical City, Riyadh, Saudi Arabia.**	EXOME SEQUENCING AND THE MANAGEMENT OF NEUROMETABOLIC DISORDERS	NEW ENGLAND JOURNAL OF MEDICINE	59.558
[1-2]Arabi YM, [1-2]Aldawood AS, [1-2]Al-Dorzi HM, [1-3]Tamim HM, [1-2]Haddad SH, [4]Jones G, et al.	[1] **King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia; [2] King Abdullah International Medical Research Center, Riyadh, Saudi Arabia**; [3] American University of Beirut- Medical Center, Department of Internal Medicine, Beirut, Lebanon; [4] University of Ottawa, Ottawa Hospital Research Institute, Department of Medicine, Ottawa, Canada; et al.	PERMISSIVE UNDERFEEDING OR STANDARD ENTERAL FEEDING IN HIGH AND LOW NUTRITIONAL RISK CRITICALLY ILL ADULTS: POST-HOC ANALYSIS OF THE PERMIT TRIAL.	AMERICAN JUORNAL OF RESPIRATORY OF CRITICAL CARE MEDICINE	13.118
[1]Sifrim A, [1-2]Hitz MP, [1, 3-4]Turki SH, [5]Omer SO, [5-7]Abu-Sulaiman RM; et al.	[1] Wellcome Trust Sanger Institute, Cambridge, UK. [2] Department of Congenital Heart Disease and Pediatric Cardiology, Universitätsklinikum Schleswig-Holstein Kiel, Kiel, Germany. ... [3] **Department of Pathology, King Abdulaziz Medical City, Riyadh, Saudi Arabia**; [4] Genetics Training Program, Harvard Medical School, Boston, Massachusetts, USA. ... [5] **Division of Pediatric Cardiology, King Abdulaziz Cardiac Center, King Abdulaziz Medical City, Ministry of National Guard-Health Affairs, Riyadh, Saudi Arabia. ... [6] King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia. [7] King Abdullah International Medical Research Center, Riyadh, Saudi Arabia**; et al.	DISTINCT GENETIC ARCHITECTURES FOR SYNDROMIC AND NONSYNDROMIC CONGENITAL HEART DEFECTS IDENTIFIED BY EXOME SEQUENCING.	NATURE GENETICS	31.616
[1]Yu H, [2]Zhang VW, [3]Stray-Pedersen A, [4]Hanson IC, ... ALZahrani D12, et al.	[1] Baylor Genetics, Houston, Tex. [2] Department of Molecular and Human Genetics, Baylor College of Medicine, Houston, Tex. [3] Department of Pediatrics, Section of Immunology, Allergy, and Rheumatology, Baylor College of Medicine and Texas Children's Hospital, Houston, Tex; [4] Department of Pediatrics, Section of Immunology, Allergy, and Rheumatology, Baylor College of Medicine and Texas Children's Hospital, Houston, Tex; [5] **Department of Pediatrics, King Saud Bin Abdulaziz University for Health Sciences, Jeddah, Saudi Arabia**; et al.	RAPID MOLECULAR DIAGNOSTICS OF SEVERE PRIMARY IMMUNODEFICIENCY DETERMINED BY USING TARGETED NEXT-GENERATION SEQUENCING.	JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY	12.485
[1]Taylor-Weiner A, [1]Travis Zack T, [2]O'Donnell E, [2]Guerriero JL, ... , [3]AlDubayan S, et al.	[1] Division of Medical Sciences, Harvard University, Boston, Massachusetts, Broad Institute of MIT and Harvard, Cambridge, Harvard Medical School, Boston, Massachusetts, USA; [2] Department of Medical Oncology, Dana-Farber Cancer Institute, Boston, Massachusetts, USA; ... [3] **Department of Medicine, King Saud bin Abdulaziz University for Health Sciences, Saudi Arabia**, Department of Cancer Biology, Dana-Farber Cancer Institute, Boston, Massachusetts, USA; et al.	GENOMIC EVOLUTION AND CHEMORESISTANCE IN GERM-CELL TUMOURS	NATURE	38.138

HELPING DRUGS WORK

A laboratory service at King Abdullah International Medical Research Center is bringing tailored monitoring of drug dosage to Saudi Arabia and beyond.

Powerful drugs are becoming more effective and safer in the treatment of disease thanks to an initiative that monitors patients' medication levels during treatment, allowing precise adjustment according to an individual's specific needs.

Treatment usually involves swallowing a pill then forgetting about it until the next dose. Some medical conditions, however, demand that the concentration of a drug at its target area in the body be maintained at a narrow, optimum range. The dose must be sufficiently high to work, but not so high as to cause dangerous side effects. This is especially true of powerful medicines used to treat cancer.

King Abdullah International Medical Research Center (KAIMRC) is responding to this challenge by offering a therapeutic drug monitoring (TDM) service. As the KAIMRC team develops its expertise, it is bringing refinements in drug dosage not previously available in Saudi Arabia, and there are plans to extend its reach across other countries in the region.

Salman Alfadhel, the researcher leading the TDM service, says the initiative grew from a decision to tackle the wider issue of weaknesses in bioanalytical capabilities in Saudi Arabia. “In 2009, [a KAIMRC] committee wanted to address concerns about the quality of generic drugs produced in Saudi Arabia, and to find ways to maximize the use of home-produced generic drugs while ensuring optimum benefits for patients,” he explains. This led to the establishment of a new KAIMRC bioanalytical lab in 2013, with the provision of TDM services as part of its remit.

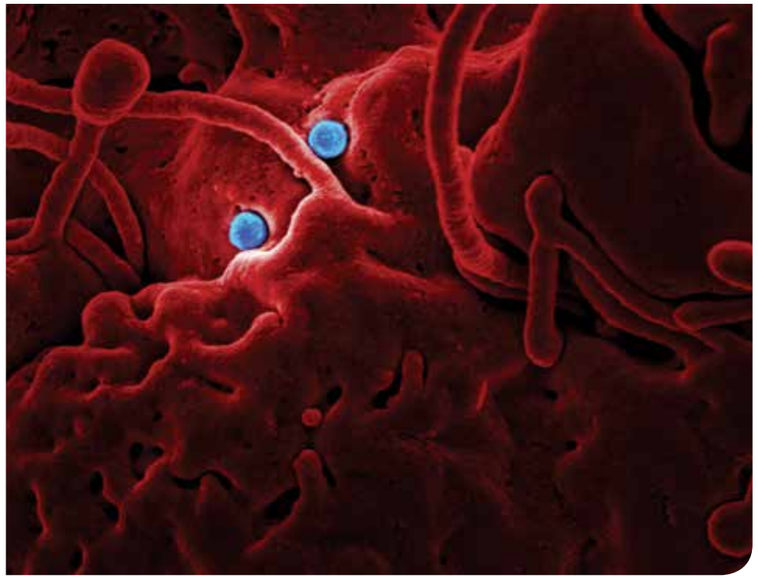
TDM involves monitoring drug levels in blood or plasma to ensure optimal concentrations in specific target tissues.

The chemical analysis procedures required to check drug levels depend on sophisticated equipment. The KAIMRC laboratories are kitted out with facilities to perform refined state-of-the-art identification and quantification.

The team already provides TDM services for all the Ministry of National Guard - Health Affairs (MNGHA) hospitals across the kingdom.

They are currently working to optimize TDM methods for drugs used to treat cancer, fungal infections and tissue rejection following transplant surgery. They are also working with clinical specialists in epilepsy to explore the possibilities for monitoring a range of anti-epileptic drugs. People can vary markedly in the level of drugs that most effectively controls epileptic seizures, making epilepsy an obvious target for the TDM approach.

TDM is a growing aspect of the KAIMRC bioanalytical work, both in terms of increasing staff numbers and widening reach. “Eventually we want to expand beyond MNG–HA hospitals and Saudi Arabia and into all the Gulf Cooperation Council countries,” says Alfadhel.



LEADING THE WAY IN MERS RESEARCH

Tackling MERS will require an international multi-pronged approach, and KAIMRC is an integral part of this.

In September 2012, the world was introduced to an unknown virus that causes severe respiratory symptoms and can lead to organ failure and death. First identified in Saudi Arabia, Middle East respiratory syndrome (MERS) is caused by a coronavirus called MERS-CoV.

There have been more than 1800 reported cases of MERS in 27 countries with an average mortality rate of about 35%, said KAIMRC virologist Naif AlHarbi. More than 1400 of those cases were reported in Saudi Arabia.

Since the discovery of the disease, KAIMRC has worked actively to study it and develop treatments and a vaccine to stop its spead.

“All peaks in [MERS-CoV] activity are dominated by hospital outbreaks,” said Maria Van Kerkhove, the head of the outbreak investigation task force at Institut Pasteur’s Center for Global Health in France.

These outbreaks could be contained, she said, because they’re mainly caused by slow isolation of suspected patients, overcrowding in emergency departments, inadequate basic infection prevention and control measures, and cultural differences in seeking out medical attention.

Countries need to raise awareness of MERS, especially those with close ties to Saudi Arabia, so that healthcare systems can identify and isolate patients early. More consistent testing of close contacts is also crucial, especially for healthcare workers and hospital cleaners. Finally, the role of asymptomatic healthcare workers in the transmission of the disease should be studied and communication should be improved between hospitals and the public.

Much research is underway to develop drugs and vaccines against the virus. One potential target, explains Mathew Fenton, director of the division of extramural activities at the US National Institute of Allergy and Infectious Diseases, is a gene sequence that is responsible for producing a protease enzyme essential for the virus’s replication.

Investigations are also targeting a part of the MERS-CoV genome that produces a ‘spike’ protein, which protrudes from the virus’s surface and binds to a receptor called DPP4 on human cells. The sequence of DNA nucleotides in the DPP4 receptor determines which hosts MERS-CoV is able to infect.

Mice and ferrets, for example, cannot be infected with the virus unless the nucleotide sequence of their DPP4 receptor is modified to become similar to that of humans. Mice models with humanized DPP4 receptors are being used for the rapid assessment of MERS therapeutics.

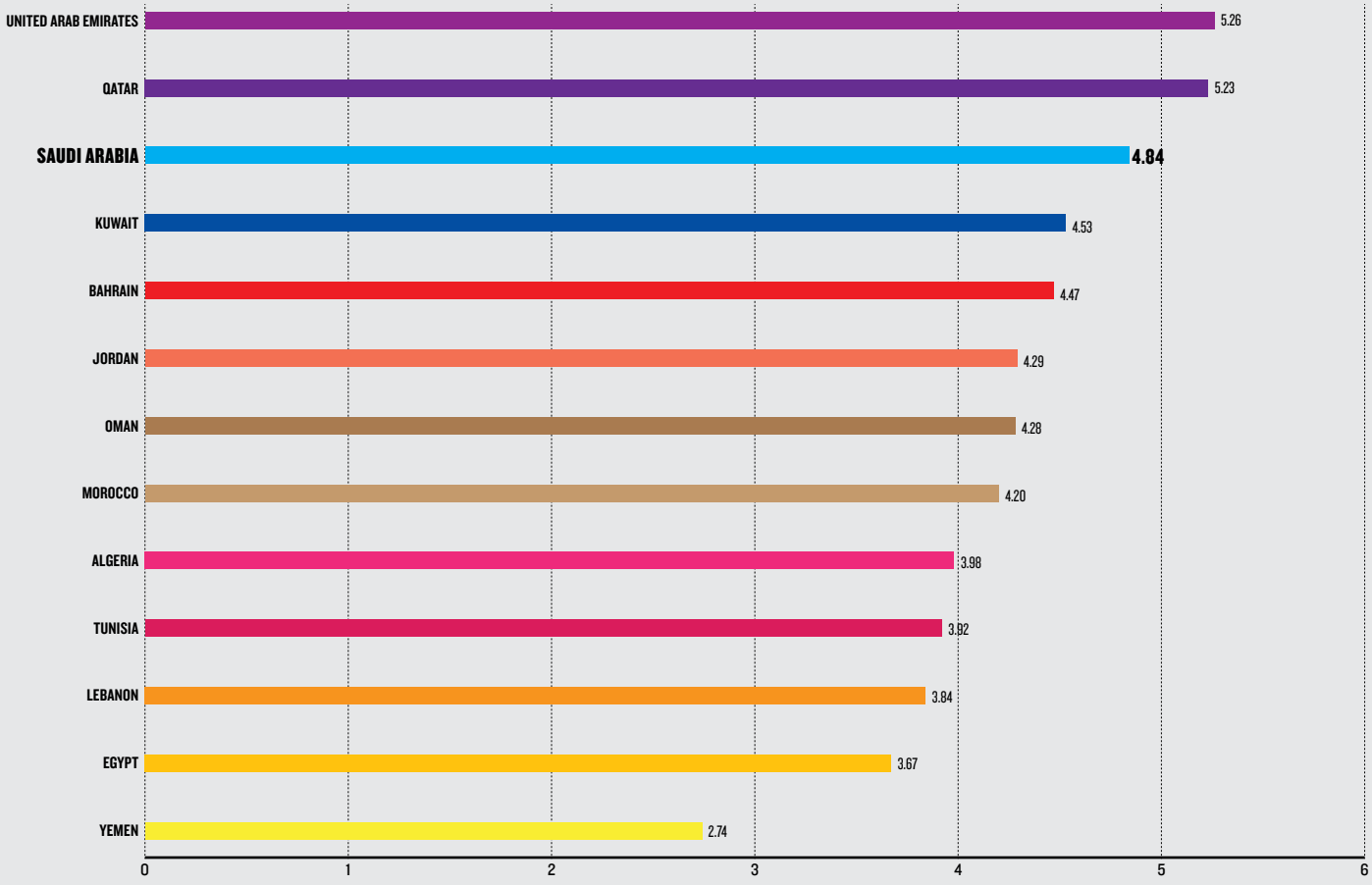
Vaccinologist Sarah Gilbert, of the University of Oxford’s Jenner Institute and her group are in the process of developing a vaccine, which could potentially be used to prevent MERS in camels and in humans.

It’s an extension of the institute’s previous work in developing ‘adenovirus vector vaccines’. In these vaccines, one virus, made safe for humans, carries a part of another virus — the one being vaccinated against — in order to stimulate a T-cell response in the vaccinated person or animal. The Jenner Institute developed an adenovirus vector from ChAdOx1, a safe inactivated form of a common cold virus. This vector is being used to develop vaccines against diseases like malaria, tuberculosis, Ebola, and prostate cancer. Preparations are currently underway to manufacture a ChAdOx1-based vaccine against MERS for use in clinical trials in 2017. Phase 1b of the vaccine trials will be conducted in collaboration with KAIMRC in Saudi Arabia. KAIMRC will also be conducting camel research trials.

KAIMRC is also in the process of developing an easily applied and rapid diagnostic test for MERS-CoV, announced the centre’s executive director, Ahmed Alaskar, during the 7th Annual Forum for Medical Research held last December.

GLOBAL COMPETITIVENESS INDEX 2016/2017

Saudi Arabia ranked 29 out of 138 states on the Global Competitiveness Index for 2016/2017, only surpassed by two other Arab states. The report, produced by the World Economic Forum, recognized the kingdom's efforts to diversify its economy through Saudi Vision 2030.



KAIMRC SCIENCE DAYS

Promoting research, exploring new opportunities. A series of science days in the KAIMRC auditorium will promote KAIMRC's strategic areas in disease throughout 2017. The first day, focused on cancer research, took place on March 5. It will be followed by events devoted to diabetes and cardiovascular, infectious and neurological diseases.

"We hope these days will allow us to explore new opportunities for collaboration, help us to move basic research into clinical trials and generally support our specific strategic research and development programs," says Abdelali Haoudi, KAIMRC's head of strategy and development.

The science days are open to researchers and clinicians from any institution, with no invitation required. Each day includes a series of presentations followed by a panel discussion with members of the audience encouraged to contribute. "The day about cancer R&D proved to be very interactive," says Haoudi, emphasizing that networking to make new contacts and explore new opportunities is one of the days' primary aims.

STEM CELL REGISTRY GETS LARGER

More than 100 awareness campaigns conducted around the kingdom have led to an increase in the number of samples available at KAIMRC's Stem Cell Donor Registry. Established in 2011, the registry aims to find compatible stem cells for patients diagnosed with conditions such as leukaemia and multiple myeloma. The registry currently includes donations from 46,000 people, more than half of whom are women. Eleven stem cell donations have already been used to treat patients in Saudi Arabia and abroad.