PHILIPPINE COUNCIL FOR HEALTH RESEARCH AND DEVELOPMENT

Health 4.0

Trends and implications for Health Research and Development in the Philippines

Contribution to the International Conference on

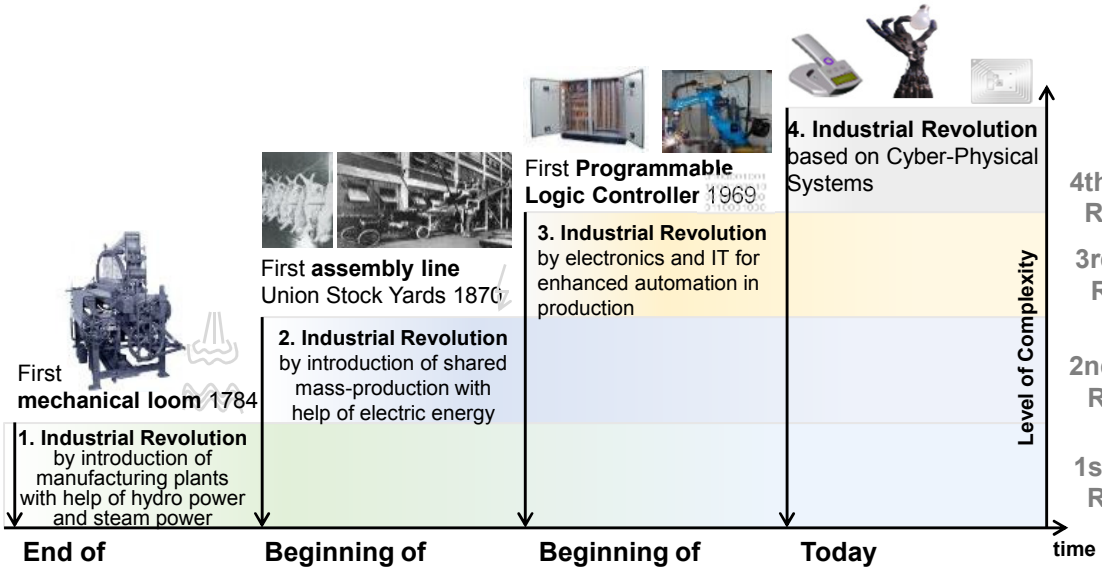
Health Research and Industry 4.0

37th Philippine Council for Health Research and Development Anniversary

Pasay City, March 15, 2019

Dr. Michael Braun

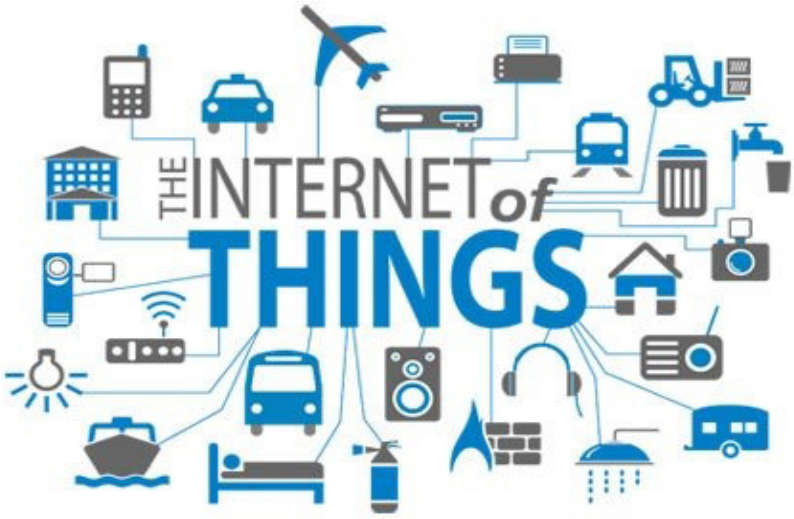
We all know this picture – but what does it mean for the Health sector?



Source: Prof. Dr.-Ing. Reiner Anderl, Industry 4.0, Presentation at GCSM, September 16, 2015, based on Kagermann, H.; Wahlster, W.; Held, J.; (Hrsg.) : Bericht der Promotorengruppe Kommunikation. Im Fokus: Das Zukunftsprojekt Industrie 4.0. Forschungsunion, 2012

1

The 'Internet of Things' creates the basis for 'Industry 4.0'



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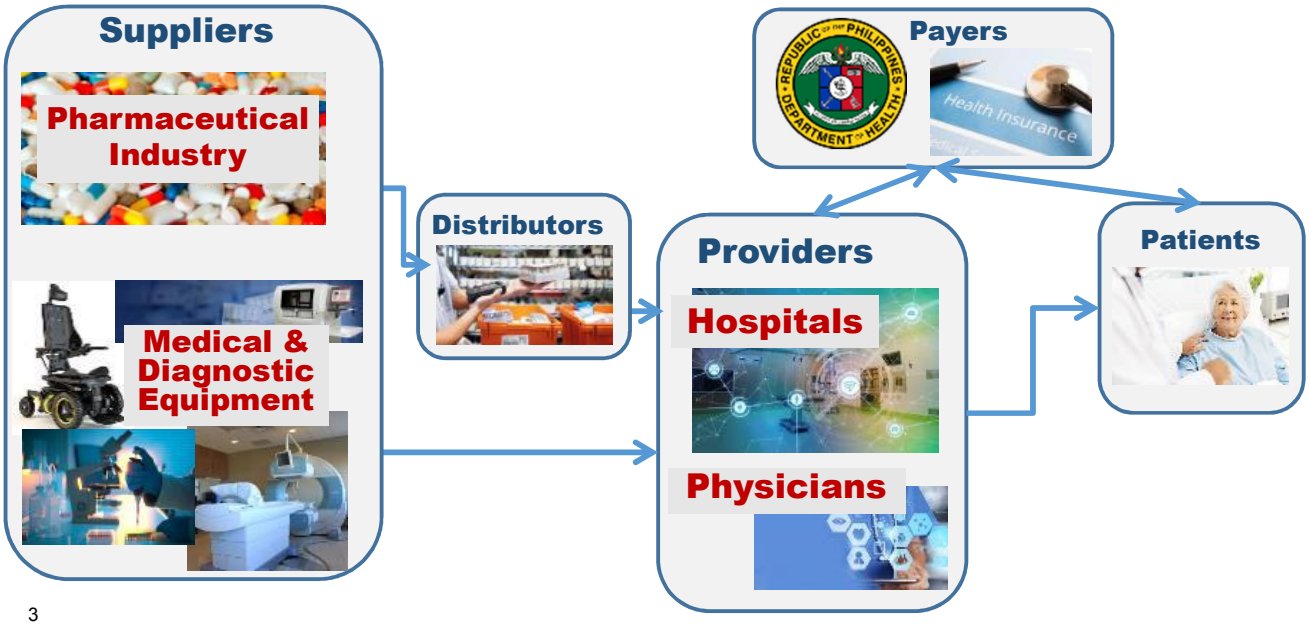
Source: http://english.vietnamnet.vn/fms/science-it/162120/vn-joining-4th-industrial-revolution.html

What impact have Industry 4.0 technologies on the Health Care value chain?



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Impact on suppliers and providers: Will IoT be a "game changer"?

Some forecasted trends

Smart phones, watches and clothes measuring important vital signs

- Measuring vital signs initially driven by sports/ leasure industry
- New devices (e.g. *Apple Watch, Omron Heartguide, Withings Move ECG* can measure clinical-grade ECG and ensure a multifaceted overview of the wearer's heart health status.
- Next steps = ECG and blood pressure smartwatches?
- Longer term: Include in clinical and diagnostic practice as "new industry standard" formats for heart monitoring, control of cardiovascular diseases, etc.?

Cars becoming Points of Care

- Driverless cars offer free time and IoT infrastructure for other activities of passengers
- Seat, steering wheel, seatbelt and other parts of the car come in contact with humans
  - *Equipment can act as a biometric sensor to measure vital signs passively and store the data in the cloud*

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Impact on suppliers and providers: Will IoT be a "game changer"?

Some forecasted trends (continued)

Connectivity of devices and cost pressure change the market structures

Genomics and Blockchain

- Exponential rise of amount of genomic data + Sharing and purchasing practices of "Direct to Consumer" companies
- Protect individuals' DNA information = new key issue?
- First start-ups experimenting: Bring genomics onto Blockchain
- Allow for data circulation to accelerate research while protecting uniquely personal information

Must we envisage future genomic big data markets? ?

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Impact on suppliers

Some use cases for Blockchain in the Pharma sector

Prevention of Counterfeit Drugs and Medical Devices

As the drug moves through the supply chain, the transactions can be recorded on a Blockchain, thereby providing a distributed provenance ledger. This will make it possible for all parties to track drugs through the entire supply chain life-cycle

Compliance in Pharma supply chain

Throughout the supply chain, environmental conditions must comply with require-ments (example temperature sensitive vaccines) need to be properly monitored. Smart IoT devices record temperature, humidity and other factors. And Blockchain's inherent transparency and immutability guarantees full transparency

Improving the quality and reliability of Clinical Trials data

Clinical trials data are stored in a secure, unfalsifiable and publicly verifiable manner This prevents tampering with clinical trials results and improves their reliability.
The decentralized nature of Blockchain gives to the patients control over their data, and consent and its revocation. Individual patients can store and control access to their medical data, and make it visible to trial recruiters.

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Connectivity is the basis of Industry 4.0
"Everything speaks with everything"

Internet of Things (IoT)

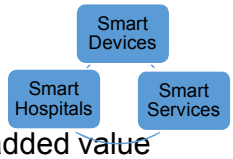
➢ **Every physical object equipped with an IPv6-address**

- IoT connects communicating objects, based on Internet technologies
- Detection and identification using IPv6-addresses
- Detection of patient parameters, location of physical objects, etc.
- "Big Data"

Internet of Services (IoS)

➢ **Service based added value processes**

- New approach to provide IoT-based services
- Concepts for disease-specific services on demand
- Combine connectivity, "Big Data" and smart devices for new services
- Improve interaction between people, machines and systems to improve added value



Internet of Data (IoD)

➢ **Manage big data: integrate product , patient and treatment data**

- Data is managed and shared using Internet technologies
- Cyber-physical systems are producing big data
- Fundamental prerequisite: Develop a holistic security and safety environment
  - *Prerequisite for dealing with sensitive patient data!*

Source: Prof. Dr.-Ing. Reiner Anderl, Industry 4.0, Presentation at GCSM, September 16, 2015

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Impact on diagnostics suppliers and providers:
Connectivity of medical devices has created its own value chain

Medical Device OEMs	• MRI, CAT, X-Ray Machine Manufacturers • Component Suppliers		SONY, SIEMENS, GE, Medtronic
Connectivity & Enablement	• Device Management • Communication Stacks • Routers and Gateways	• Silicon, Boards, and Modules	ARM, Xmc10, Qualcomm, intel, NXP
Network Services	• Wireline • WPAN • WLAN	• WWAN	orange, vodafone, at&t, verizon
Middleware & Application Platforms	• Data Aggregation, Transformation and Edge Processing • Data Analytics • Application Enablement	• Device Diagnostics and Prognostics	imshealth, amazon web services, enlitic, ARTERYS
Distribution Channels	• VARs • ISVs • Direct Sales		AIRSTRIP, PREMIER, HealthLine, ELEKTA
System Integrators & Services Delivery	• Packing and Bundling • Solution Build-Up • Consulting and Strategy Planning	• Financial Billing • Operations / Care Management • Hospital Information / EHRs	Cerner, Epic, NEXTGEN, MCKESSON

Source: harbor research; http://harborresearch.com/healthcare/

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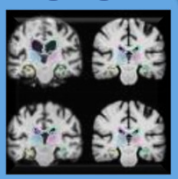
Impact on suppliers and providers:
Artificial Intelligence in the Health Sector

Some examples

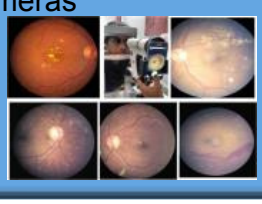
Medical imaging



- Comparing 3D medical scans is time consuming and prone to errors
- machine learning algorithm can analyze 3D scans up to 1,000 times faster → study changes almost in real time
- Algorithm trained on thousands of image pairs to learn how to align scans and provide comparisons
- Very useful for surgeons to trace progress during surgery

Diagnosis

- Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence
- Algorithm clinically trained and validated using retinal images of >78,000 patients taken using conventional desktop mydriatic fundus cameras



Digital consultation

- Emerging apps use AI to give medical consultation based on personal medical history and common medical knowledge
- Users report their symptoms into the app
- The app uses speech recognition to compare against a database of illnesses
- The app then offers a recommended action, taking into account the user's medical history

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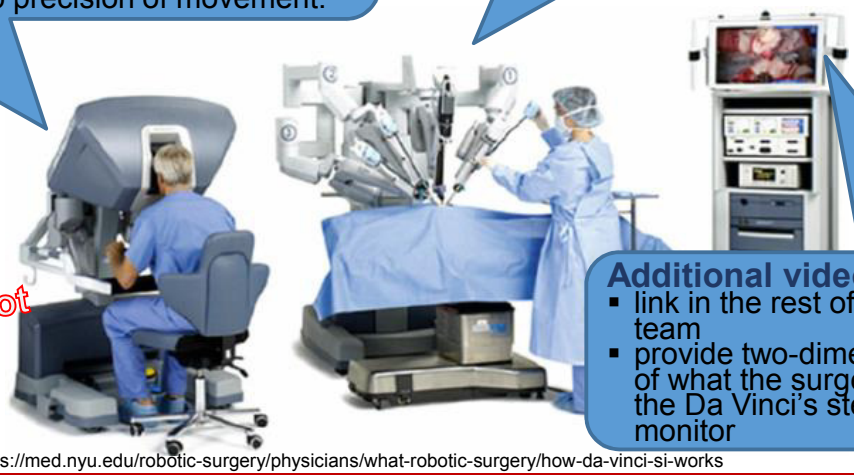
Impact on providers:
Example Robotic Surgery

Console
- Surgeon operates the robot's controls
- Stereoscopic monitor provides a magnified, high definition 3-D view of the surgical site
- Surgeon manipulates the robot's four arms by maneuvering two master controls that provide fingertip precision of movement.

Tower
- positioned over the patient during surgery
- contains the robot's four arms
- three hold different surgical instruments
- fourth holds system's 3-D cameras
- Computer-controlled arms replicate exactly the movements of the operating surgeon.



Example: Da Vinci Si Surgical Robot

Additional video screens
- link in the rest of the surgical team
- provide two-dimensional view of what the surgeon sees in the Da Vinci's stereoscopic monitor

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Source: https://med.nyu.edu/robotic-surgery/physicians/what-robotic-surgery/how-da-vinci-si-works

Impact on providers:
Example Robotic Surgery

Some milestones of computer surgery

1983 Arthrobot: First robot to assist in surgery: orthopedic surgical procedure on 12 March 1984, at the UBC Hospital in Vancouver

1985 A robot used to place a needle for a brain biopsy using CT guidance

1998 First robotically assisted heart bypass

2006 First artificial intelligence doctor-conducted unassisted robotic surgery conducted (to correct heart arrythmia; machine had a database of 10,000 similar operations) → results were rated as better than an above-average human surgeon

2008 First image-guided MR-compatible robotic neurosurgical procedure performed

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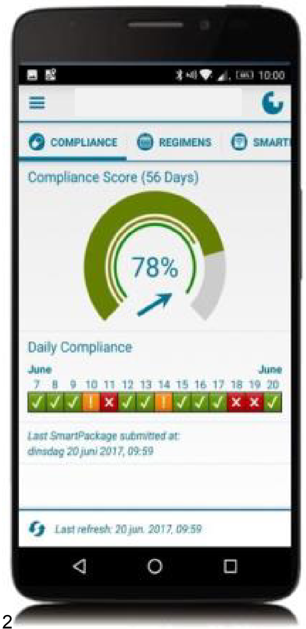
Source: Wikipedia

Impact on patients:
Example Adherence



- **Poor adherence to treatment schemes is a severe problem:** >50% of patient population don't adhere to treatment schedules
- **Trigger early and patient-safe responses to non-adherence**
- **Remind patients to take medication in near real time**
- **Smart packs monitor if the right dose is taken at the right time**
- **Graphical feed back of adherence to subject itself**
- **Early notification of non-adherence to treating medical staff**

Example:
Smart labels equipped with a near-field communication (NFC) chip and/or QR support adherence

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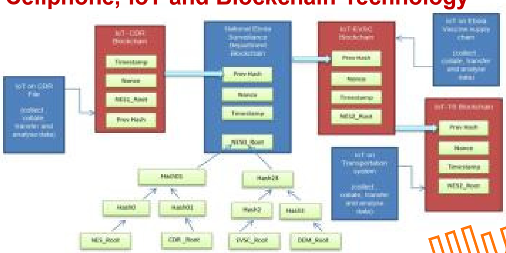
What additional role can Industry4.0 technologies play in the health sector of emerging countries?

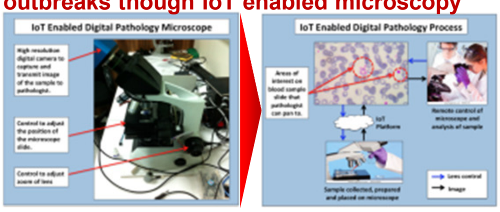
Disease & pandemic control
Example: Tracking Ebola through Cellphone, IoT and Blockchain Technology



Remote diagnosis and patient care
Example: Dengue diagnosis and patient care

Illustrative examples

Remote virus detection
Example: Remote detection of viral outbreaks though IoT enabled microscopy



Telemedicine
Example: IoT-enabled telemedicine consultations

Sources:
Jia Bainga Kangbai, Peter Bai Jame, Sulaiman Mandoh, Abu Bakarr Fofanah, Angella George, Abdulai Briama, Momodu Massaquoi, John L McBrayer (2018), Tracking Ebola through cellphone, internet of things and Blockchain technology, Curr Res Integr Med Vol 3 No S1 Winter 2018 / Deepak Puri, Using IoT-enabled microscopes to fight epidemic outbreaks, https://www.networkworld.com/article/3074319/using-iot-enabled-microscopes-to-fight-epidemic-outbreaks.html / Lakshmi and Karthik, Dengue Identification and Patient Care Monitoring Using Internet of Medical Things, J Health Inform Manag. 2017, 1:2 / Jerrid Matthews1, Rajan Kulkarni2, George Whitesides3, Majid Sarrafzadeh1, MarioGerla1, Tammara Masse, A Light-weight Solution for Real-Time DengueDetection using Mobile Phones, / ttp://nrlweb.cs.ucla.edu/nrlweb/publication/download/529/WQE_Paper_Jerrid_mobicaseV4.pdf

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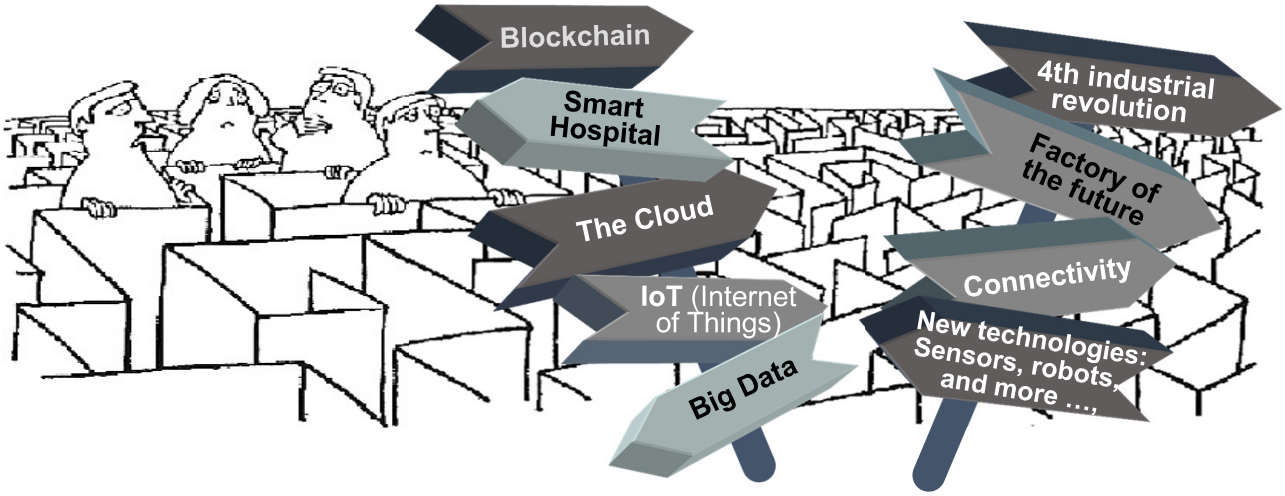
So what does "Health 4.0" mean for us in the Philippines?



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The *National Unified Health Research Agenda* offers a number of access points for Industry 4.0-oriented R&D

Research arras with possible linkages to Industry 4.0

1. **Responsive health systems**
   - Health information systems: Research on translating health data to information and knowledge, innovative health information systems to support service delivery
   - Health service delivery: Research on how to make quality health services more accessible, effective, efficient, and available and more sustainable.
5. **Global competitiveness and innovation in health**
   - Diagnostics: Development of diagnostic tests and devices
   - Drug discovery and development
   - Information and communication technologies for health
6. **Research in equity and health**
   - Geographically isolated and disadvantaged areas: access to health
   - Geriatric care: Research on appropriate health programs and services

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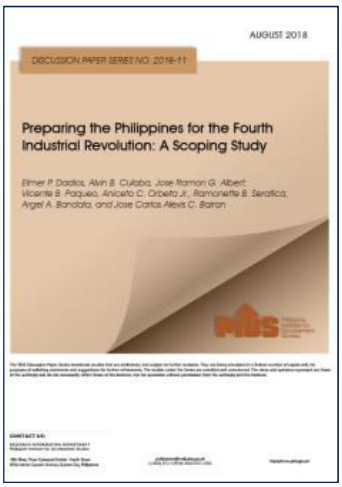
The Philippines have identified *Industry 4.0 a*s a national priority … … but its "Industry 4.0 readiness" is still low



Research arras with possible linkages to Industry 4.0

- **Disruptive technologies with high relevance for the Philippines**
  - Internet of Things
  - Artificial Intelligence
  - Blockchain
  - Big Data
  - Robotics
  - Neurotech
  - Nanomaterials
  - Additive Manufacturing
  - Cloud computing
  - Energy Storage
  - Synthetic Biology
- **Some conclusions**
  - Full advantage of the FIRe requires to overcome "business-as-usual attitude.
  - As a developing country, the Philippines must pay special attention to developing complementary capabilities
  - First establish a solid basic foundation for sustained learning and on accumulating various types of capital, while progressively closing the existing technological and knowledge gaps.
  - Systematically review and adapt policies, institutions and development efforts in light of upcoming revolutionary changes

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Can other R&D instruments support to develop of Industry 4.0 in the Health sector?

Examples from Philippines' Science for Change Program (S4CP)

Collaborative Research and Development to Leverage Philippine Economy (CRADLE)

- Bridge the academia and industry to create seamless innovation chains leading to outputs for practical applications;
- Stimulate collaboration that meets the needs of both academia and industry
- 4 pillars:
  - ***CRADLE 1***: Collaborative Basic Research Based on Industry Demand
  - ***CRADLE 2***: Academe-Industry Joint Commissioned R&D
  - ***CRADLE 3***: Product Development Stage
  - ***CRADLE 4***: Promotion and Access to Technologies for Industry Competitiveness

Business Innovation through S&T (BIST) for Industry

- Strengthen S&T innovation activities and technological capacity of private sector
- Support purchase of relevant high-tech equipment and machinery, technology licensing, and acquisition of Intellectual Property

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Source: USec. RCL Guevara Presentation at the 2nd National R&D Conference, February 15, 2017

Build on existing strengths

National Telehealth Center

Mission

- To engage communities in the design, development and use of appropriate and progressive ICTs towards better equity in health

Research Programs

- eLearning and Capacity Building for Health
- eMedicine
- eRecords
- eSurveillance
- eHealth and eHealth policy Advocacy

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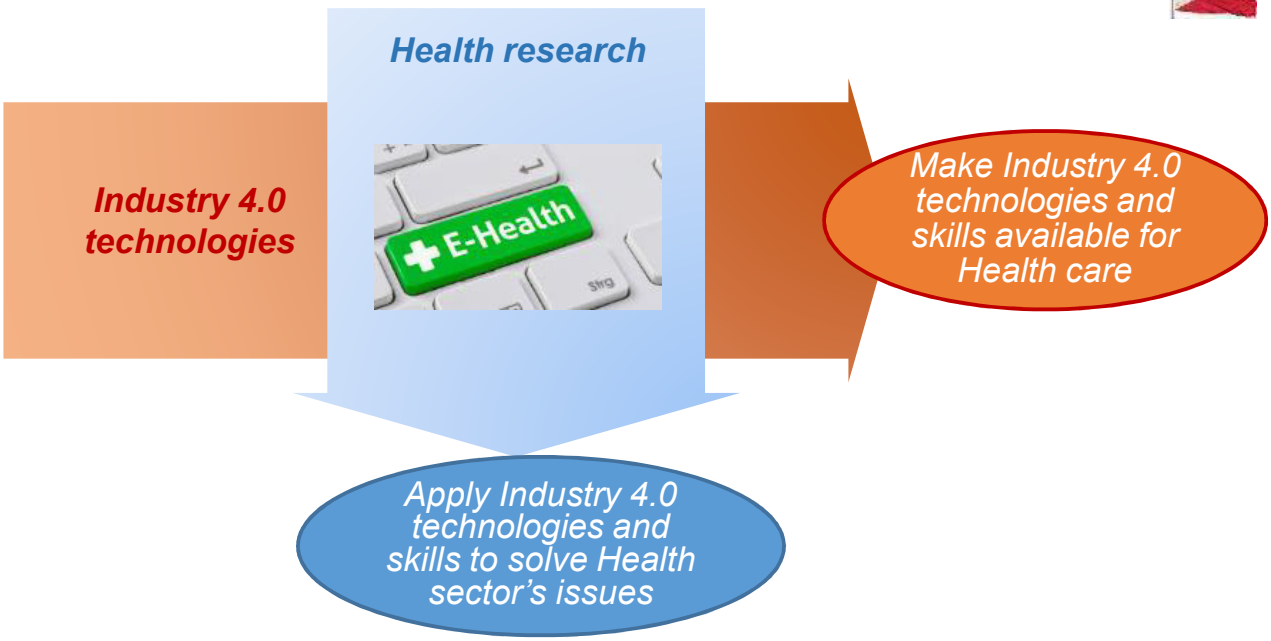
Make research into Health 4.0 truly interdisciplinary



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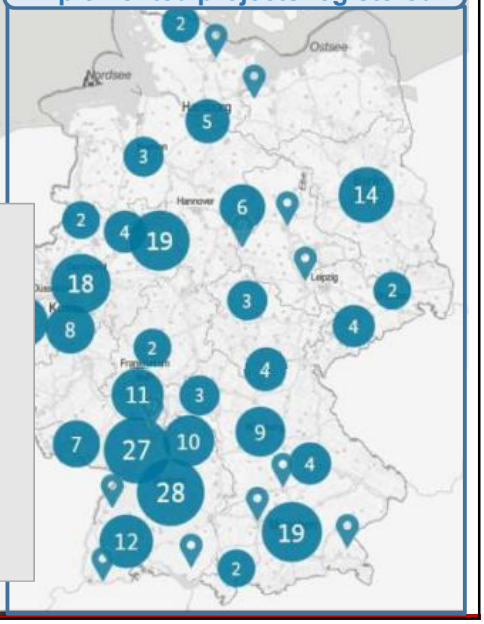
Coordinate individual projects to create momentum and use synergies

Industry 4.0 map Germany: 251 implemented projects registered!



- **Primary objective: Secure and develop Germany's top international position in industrial manufacturing**
- **Promote digital structural change and provide the consistent and reliable framework necessary for this.**
- **Develop a consistent shared understanding of Industry 4.0 through dialogue with businesses, trade unions, science and government.**
- **Draw up relevant recommendations for action.**
- **Stimulate and support science-industry cooperation**
- **Demonstrate potential of next generation industrial manufacturing through example applications.**

Source: http://www.plattform-i40.de/I40/Navigation/Karte/SiteGlobals/Forms/Formulare/karte-anwendungsbeispiele-formular.html;jsessionid=9C31401FEF80F7F078538456D1B58CE6

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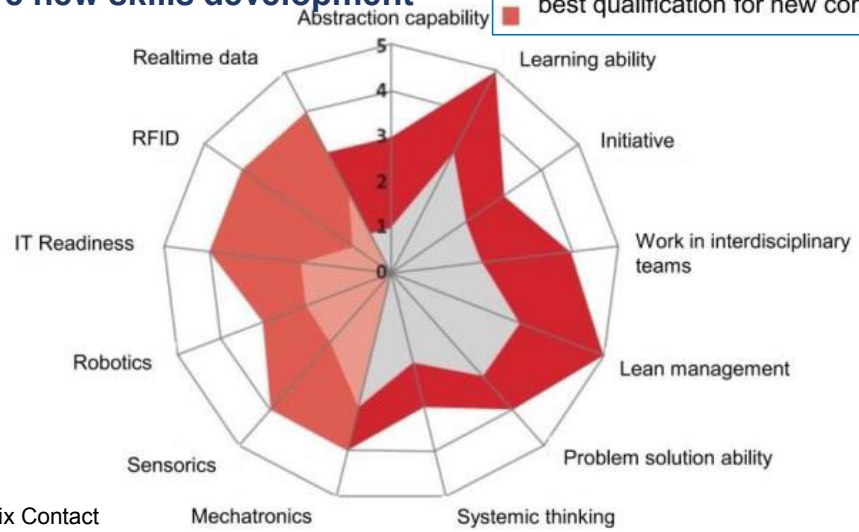
Develop the new profiles and skills required under Health 4.0

Example from mechanical engineering:
New required competences of maintenance technicians require new skills development



Source: Phonix Contact

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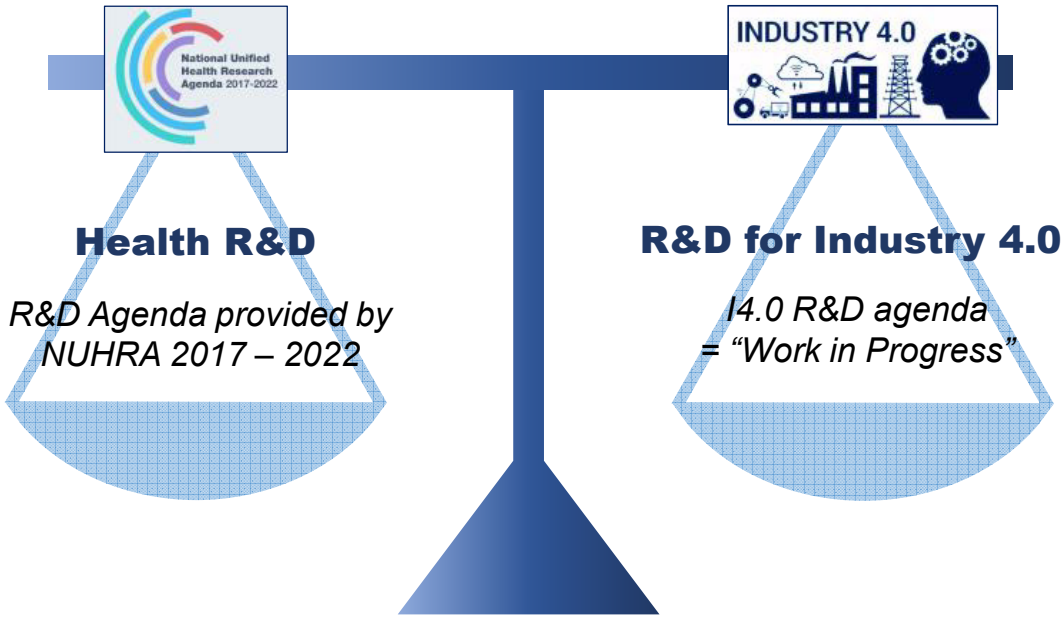
Successful development of Health 4.0 requires to move from sector-oriented R&D towards interdiscipinary R&D



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Create opportunities for start-ups to develop and commercialize IoT and Industry 4.0-bases solutions in the health sector

Example: Start-up offering IoT-enabled full service for telemedicine

intelehealth

- **Not-for-profit social enterprise**
- **Vision: Improve access to comprehensive primary health care for remote & underserved communities through telemedicine**
- **mobile-based telemedicine platform**
- **Comprehensive offering:**
  - Software
  - Expert system
  - Point of care diagnostics
  - Consulting/implementation support for health organizations

Source: https://www.intelehealth.org/

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Key elements of integrated Telemedicine offering

Cloud-based software platform

Open source telemedicine platform

- empowers local community health workers in rural communities to provide access to primary patient care
- consists of a mobile app for health workers and a cloud based electronic health record system as a backend
- App works very low bandwidth connections as well as offline

The platform contains modules for

- Healthcare provider decision support (knowledge-enabled expert system – *HxGuide*)
- Telemedicine for audio/video teleconsultations in low bandwidth environment and transmission of medical data to remote doctors
- Point of care diagnostic tests using low cost, IoT-enabled devices
- Prescription and Medication forwarding
- Referral co-ordination to guide patients to specialists
- Patient education and counselling through video resources
- Patient management, electronic health records and data reporting

Source: https://www.intelehealth.org/

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Key elements of integrated Telemedicine offering

Expert system HxGuide

Role of expert system

- Enable task-shifting of complex care processes such a history-taking, physical examination and disease management
- History-taking protocols cover over 67 conditions and 143 basic physical exams
- Provides screening for a number of primary care conditions
- Reduces time spent for data gathering and enables structured data collection for analysis.
- Output = concise history note as starting point for the doctor to develop a treatment plan with the health worker and the patient

Point-of-care diagnostic kit

Commercially available point-of-care equipment needed by local health workers, e.g.

- Portable printer
- Digital Weighing scale
- Glucometer
- Digital BP monitor
- Pulse Oximeter
- Digital Thermometer
- Hemoglobinometer
- Electrocardiogram
- Electronic Stethoscope
- Rapid Diagnostic Test for Malaria
- Mid-upper arm and head circumference, height tape
- Sanitation kit, Apron, Backpack, Emergency light

Source: https://www.intelehealth.org/

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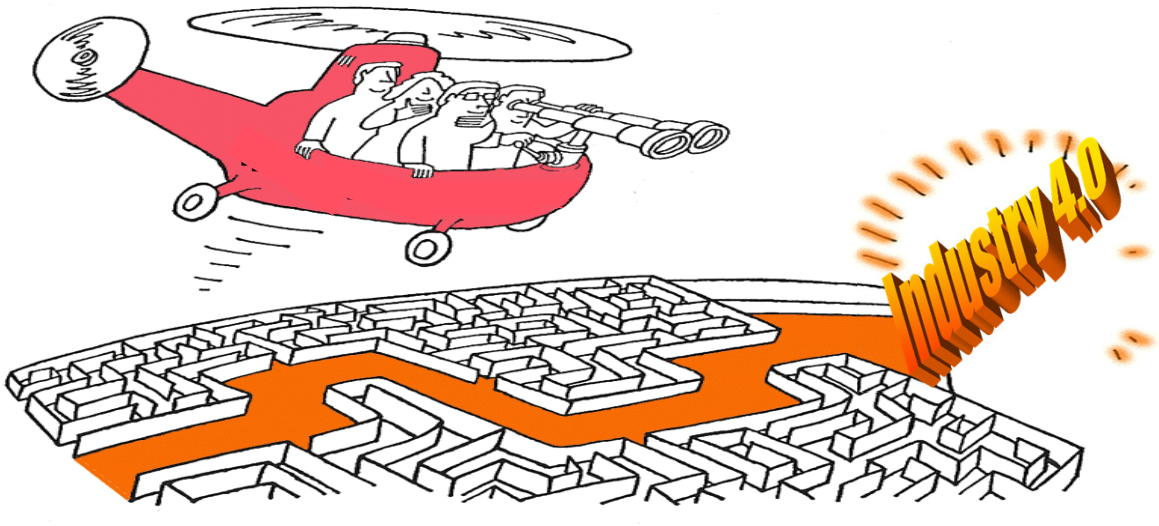
The goal:
Strategic approach to Industry 4.0



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