The Future of Sensors and Older Adults

Knowing Matters

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EXECUTIVE SUMMARY

As an aging population faces a dwindling care workforce, sensor technology is emerging that can assist organizations that provide care and help older adults to maintain independence. A fragmented market today is comprised of environmental, safety, health and movement technologies that capitalize on and extend the Internet of Things (IoT). These sensors already enable recording and deployment of AI to inform about status and predict future changes. Moving forward, they will contribute to improving delivery of care with just-right alerts and useful analytics. Multiple barriers remain, including the difficulty and cost of integration of sensors.

Over the next five years and beyond, the care industries will make more effective use of sensor technologies for detecting change in behavior. We will see expansion of Wi-Fi access in senior care. Older adults will benefit from introduction of 'Edge computing' in which device data is analyzed closer to the user. Older adults will benefit from the ubiquity of voice, AI and camera technology in their home/residence of choice. The cost of care will be rightsized – matching care capacity and improved wages for workers. And increasingly, insurers and care providers will include the role of sensors in the standard of care.

"The wall-mounted Lidar sensor talks to the patient in their language. 'Please don't get up, someone will help you.'" – Deepak Gaddipati, **VirtuSense**

INTRODUCTION

Although sensors emerged as useful senior-related technologies more than a decade ago, their use was limited. Today's perfect storm of tech innovation, labor shortage, and cost of care combine to make the use of sensors not only possible, but increasingly necessary.

WHO SHOULD READ THIS REPORT?

- Investors and funds that focus on older adults
- Senior living organizations and professional home and health care companies
- Vendors within or considering entry into the remote care technology categories
- Technology platform providers
- Telecommunication carriers
- Social services and non-profits with focus on older adults
- Healthcare providers, health systems and health plans – especially those that serve Medicare enrollees
- Life science companies entering the digital therapeutics space

ACKNOWLEDGEMENTS

This report is based on interviews held with experts and executives from 28 organizations, all of them engaged in design, analysis, or deployment of sensor technology. All were asked to look out into the future about the possibilities for this market.

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AGING AT HOME ALONE OR IN SENIOR CARE SETTINGS

An aging population faces a dwindling care workforce – and a desire to stay put. 2022 has produced a series of simultaneous trends that put technology on notice. More than 10 million people will be living longer and in their own homes (see **Figure 1**). And the population with Alzheimer's has grown to nearly 7 million (see **Figure 2**). The demand for home care workers, typically women, outpaces other types of care (see **Figure 3**). This growth signals a demand for workers to help both in-home and in senior living (see **Figure 4**). And according to CDC data, family caregivers are suffering a mental health crisis – over half indicating a decline in their health compromises their ability to provide care.

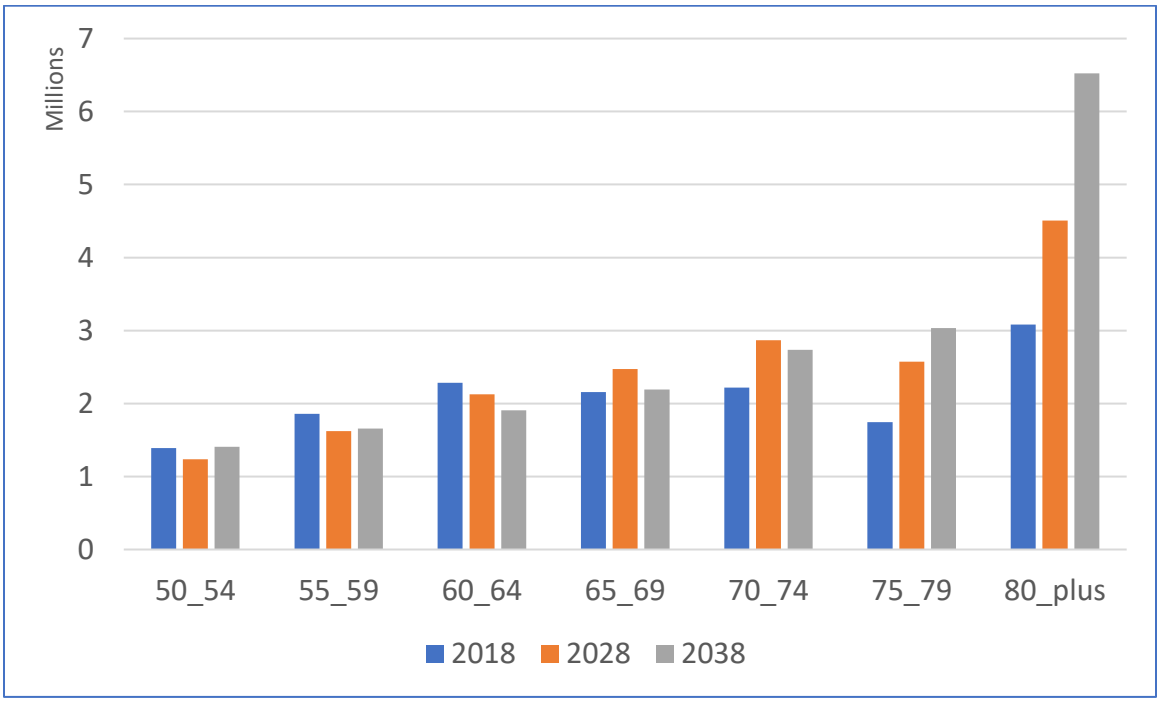

Figure 1 Single person older households Age 80+ by 2038 **Source: JCHS**

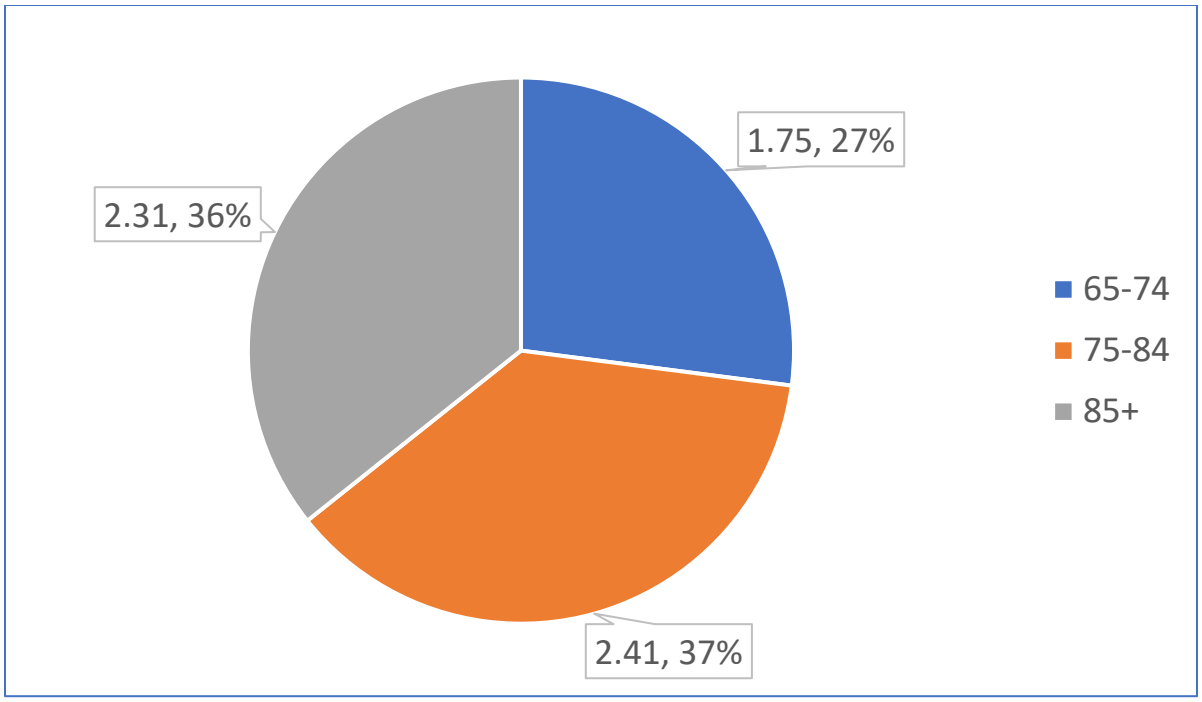

Figure 2 Number, Ages 65 or Older with Alzheimer's (millions), 2022 Source: Alz.org

Senior communities and home care services are challenged to staff up needed care.

The context for the role of sensors in care delivery is sharply defined by labor shortages throughout the care-related industries. According to PHI International, worker demand has grown 120% in the past 10 years and is expected to grow more than any other job category. Seventy-four percent of people with disabilities and seniors were unable to retain home care workers in 2021. And articles about shortages of care workers are stacking up: NPR (May 2022), Politico (July 2022), and the New York Times (July 2022).

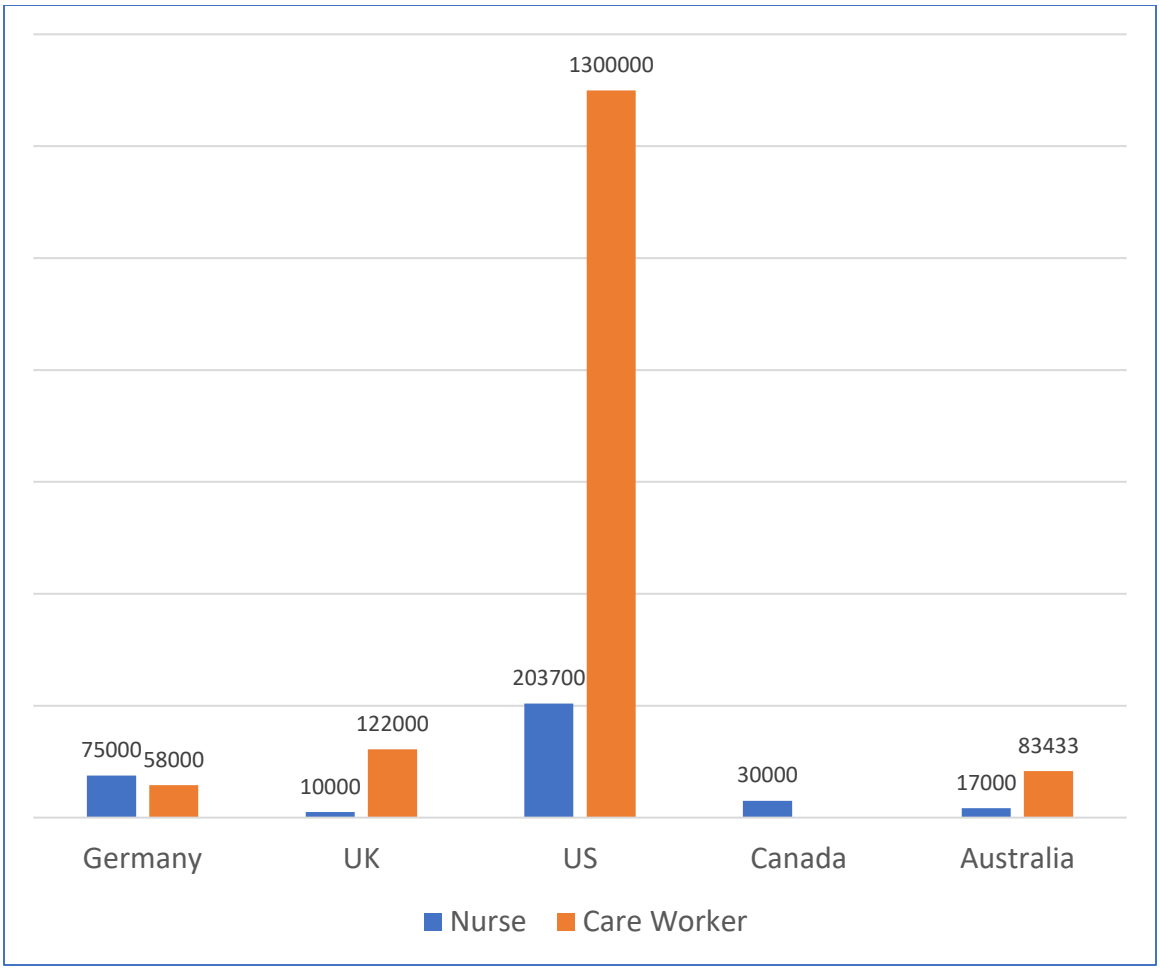

Figure 3 Care Worker shortages as of 2020 Source: Center for Global Development

Aging brings accompanying health issues and risks. More than one in four older adults fall each year, whether tripping on a rug, slipping on a wet floor or experiencing health-related symptoms. Falls represent the leading cause of death from injury. Older adults living alone at home or in a community face multiple safety risks that they or their adult children hope to prevent or at least detect. Even in staffed senior living communities, where family or care workers may be present, technologies may play a larger role in improving the odds of aging in (the right) place for older adult ages 80 and beyond.

"Families come to a home care agency or senior living community, and they have sticker shock. But passive monitoring technology could supplement family or home care." – Nathalie de Vazeille**, StackCare**

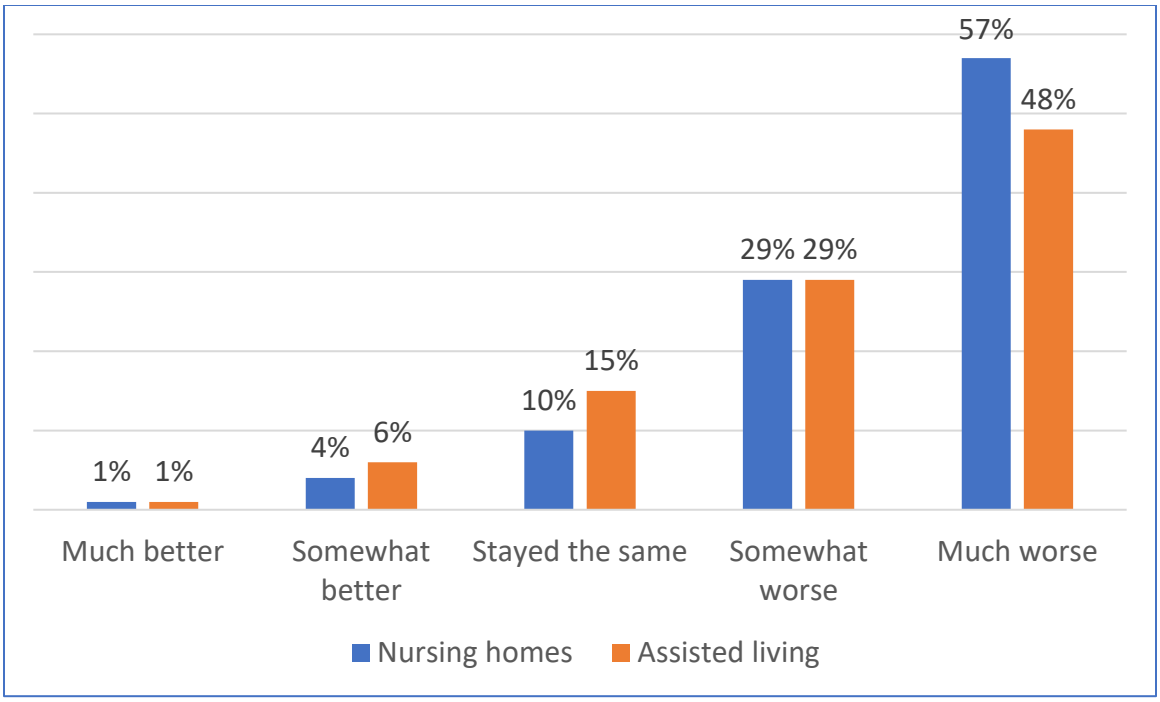

Figure 4 Shortage of senior living workers in 2021 worsens Source: AHCA NCAL

Despite labor challenges, care industries have been slow to adopt technology...

Even with the care shortages – companies struggle with a myriad of barriers and concerns about the adoption of technology for their businesses. By 2022, approximately half of the assisted living organizations in the US had high-speed Internet access to the resident units. Nursing homes had an even a lower penetration of broadband outside of common areas. And the home care industry has, to date, been hesitant to accommodate the cost of technology for franchises and workers – despite the difficulty of meeting care needs today. Some of that reluctance may have been cost, lack of tech support skills, or concerns about a tech vendor's staying power.

"The home care operator worries – who will monitor and will pay for it? But it is an investment in the business. It is like asking who will pay for the receptionist. Consider a gym – no one suggests that the members pay for the treadmills." **–** Laura Mitchell**, GrandCare Systems**

…But that is changing post Covid-19. Technologies today may be more compelling. Why? It is increasingly difficult to fill home care shift minimums of 4 hours at a time, especially considering the cost of gas it may take to get there. And there may not be enough home care workers to drive to homes where the need may be greatest. Further, the shortage in senior living communities, including nursing homes, may seem even worse – multiple residents with dementia and incontinence can keep a short-staffed community of workers running. In the context of this crisis, the evolution of sensor technologies, including lower price and easier deployment, has begun to catch the interest of senior care organizations.

THE ROLE OF SENSORS IN TODAY'S WORLD OF CARE

Use of sensors of multiple types is possible today... Sensor technologies are increasingly playing a role in the care and wellbeing of older adults. Whether it is a room-based ambient sensor, or variants like motion, LiDAR, or fall detection sensors, Wi-Fi sensing, smart cushion pressure sensors or wearable sensors. In addition to these categories, sound sensing (like falls or changes in voice) can also be relevant. Increasingly these sensors have the potential for enabling greater efficiency in delivering care in senior living or home care, as well as helping to preserve older adult independence at home for as long as possible. And it could be that sensors' greatest potential, still unrealized, will be in detecting patterns, deploying learning from those patterns, and predicting improvement and/or preventing future problems for the aging or ailing person.

…But the landscape is fragmented. Too often sensor-based offerings are sold piecemeal – value must exceed the device cost plus the integration effort. Interviewees informing this report represented multiples of those individual products shown in **Figure 5** below – a camera over here, a motion sensor over there. While pilots and integration efforts are underway – companies that might benefit say that it is not straightforward to plug a new device into an existing ecosystem. And efforts are only beginning that will deliver a standard that is applicable across all home devices.

"*As for the manufacturers, lots of smart people – they are making amazing things for themselves. No clue who the consumer is."* **–** Ryan Herd, **Caregiver Smart Solutions**

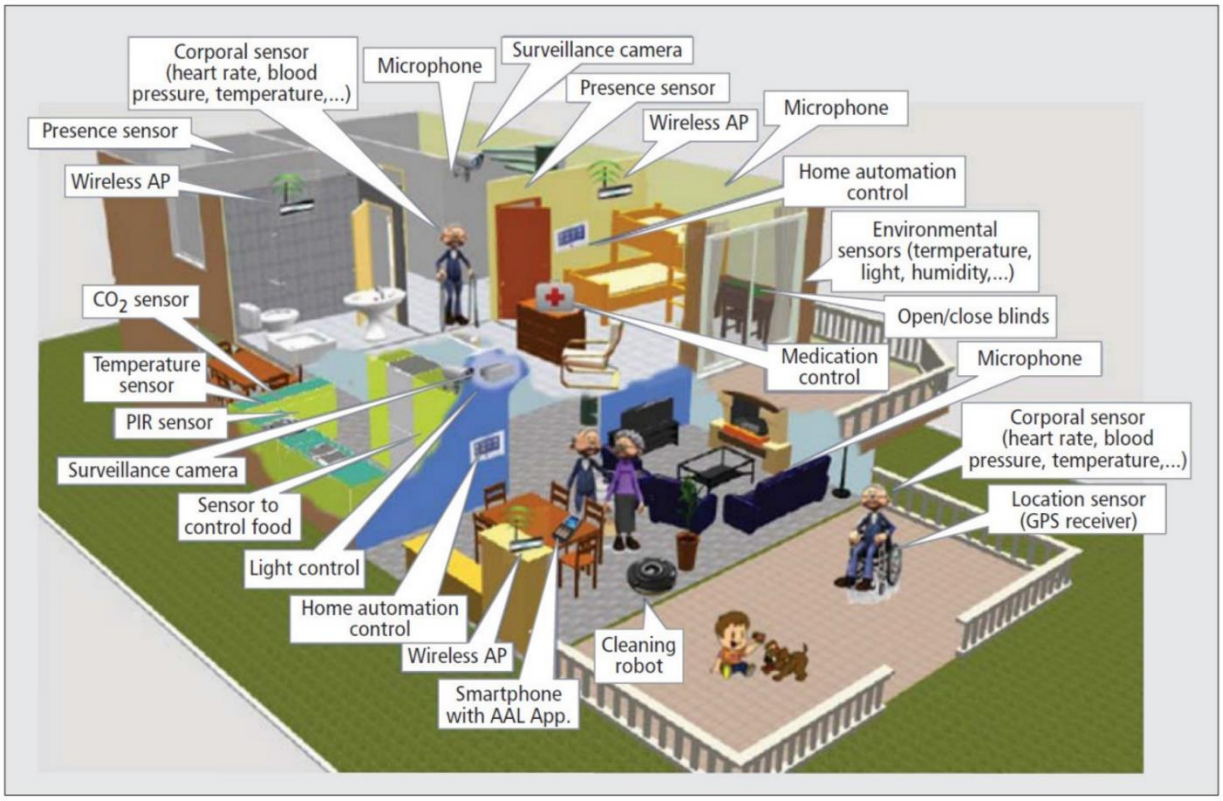

Figure 5 Ambient sensors for an older adult **Source: MDPI**

What are the types of sensors in the market today?

The image in **Figure 5** implies that all sensors play well together in the service of older adults. That figure is drawn from a comprehensive technology review published in 2021. But today each is deployed either as part of a vendor-specific solution, or custom-integrated by housing developers or smart home installers. Here are predominant categories of sensing technologies on the market today, with more being developed:

Camera – in-home only or streamed to the cloud. Security cameras have long been used in or around a home to detect visitors, delivery people at the door, or traffic around the home when owners are away. And family members and older adults have resisted technologies that were perceived as invasions of privacy. But newer offerings on the market have been introduced to help with remote monitoring and fall detection that do not show actual images of individuals, but rather use their imaging capability to determine locally (aka at the 'Edge') if alerting is required. These include modified images with Vayyar Care (part of Amazon's Alexa Together), and offerings from VirtuSense, Kami Care, and SafelyYou.

AI-enabled motion/movement – or lack thereof. Motion sensing emerged more than a decade ago as part of the care of older adults. Placed sensors in the home could detect whether a person is up and about, had left the home, or perhaps had a fall – notably without a wearable on the

body. Most of these startups did not survive, likely from a combination of factors: the cost of product or implementation was high, the network access was spotty, investors lost interest, or more simply, the market timing was not yet right.

Internet of Things – alerting the landscape. Times have changed. The Internet of Things (IoT) emerged and became a feature of the Smart Home, thus offering new possibilities for remote monitoring of older adults living alone. Today motion sensing is now one of the AI-powered features offered by companies like Caspar.ai, Zemplee, StackCare, and SensorsCall. And more new players arrive regularly, including AI-enabled Origin Wireless (Wi-Fi fall detection), Labrador Systems (AI-sensing robots), Kalogon (pressure sensing cushions) and CareDaily (AI-assisted IoT).

Sensor information can contribute to wellbeing

In-home or in-community sensors of multiple types are on the market today. These use light or energy changes, such as Passive Infrared (PIR) sensing or Infrared (IR) sensing. Sensors can be based on in-home Wi-Fi, heat or motion sensing, gait changes, fall detection devices, and even the sound of falling. Sensors can be especially helpful during those periods of the day or night when an older person is alone. They can assist in tracking behavior changes, minimizing risk, and averting problems that can result in hospitalization or worse. Sensor problem sets can be generally categorized as environmental, activity-based, or health-focused:

- **Environmental (temperature, moisture, light, gas, smoke, fire, sound).** Family members worry about aging parents living alone and worry about their forgetfulness – for example, the risk of fire from a stove left on, or a flood from an unattended faucet. Tech is available today to make sure the stove is turned off when residents leave home; or they can alert in the event of a fire (for example, iGuardFire), as well as noticing when a faucet is left on. The notification could, alternatively, come from a Wi-Fi enabled smoke and carbon monoxide detector for example, from Kidde or as part of a home security system (such as a suite from ADT).

- **Activity based -- presence or movement in the home.** The category of sensors for well-being can detect whether a family member has returned from dinner or an outing, or whose departure was not monitored. These can be placed in the home or on the body. They can utilize types of heat (warm body or PIR) sensing, as well as accelerometers for fall detection. Air Tags on a belt or wrist can be used for tracking family members with dementia or more traditional GPS location tracking on the wrist or via pendant-worn wearables.

- **Health-focused.** According to Parks Associates, 54% of US households own a connected health device, either provider-prescribed or purchased by the consumer. As more individuals adopt devices that track vital signs – health risks may be better managed. These health signals include vital sign tracking such as respiration and

monitoring of EKG changes. Some devices, including smartphone apps, could be used in a room. Or information can be collected from a wearable device or sensor on the body**.**

"Medical sensors for the most part are still silos. Bringing that all together with other existing sensors in the home into a useful always-on service will better allow the elderly to stay in their own homes." – Mike Mazzola, CEO, **Lamprey Networks, Inc.**

Sensors enable recording and analyzing change over time

Patterns and corresponding analytics make the difference. While useful as a tool to avert a problem, the real benefit from sensor data will be in the analytics and predictions that sensors enable. Simple sensors can be combined through data collection and AI into warning signals of changes that matter. It may seem obvious, but these must be combined with robust (and frequently updated) profiles of individual patients or care recipients, to determine which changes are significant. For example, based on a quantified fall risk score, older adults could be encouraged to obtain Physical Therapy for strength and improved bone density. What capabilities exist today to track important changes and enable recommendations?

"The prior sensing technology was binary – is there movement, YES/NO. Data coming out of solutions today requires specific analysis, quantifying fall risk, for example." c Kristen Hanich, **Parks Associates**

- **Signs of health decline – bathroom trips and UTIs.** Whether at home or in senior living, there are multiple uses of health sensors for older adults. For example, they can be used to detect whether a person is breathing or exhibits symptoms of COPD or Sleep Apnea. And a smart scale like Zibrio's can record data to detect change in balance over time. Patterns of behavior can suggest the possibility of a urinary tract infection (UTI).

  "These apartments we manage can grow with you (starting at your move-in stage). We will use technology to detect when human intervention is needed." – Jake Rothstein, **Upside**

- **Early detection that averts health crises.** Whether it is blood pressure, weight scales, gait analysis, fall detection or changes in cardiac status, sensors in the home can help avoid hospitalizations for older adults with chronic conditions. But today the data from these are passed separately from sensor to in-home AI or more likely to the cloud.

  "Firms have told us they need a "Future of Sensors Strategy" – our offering provides AI bots listening to streams of data – ranking patients for 'human attention needed.'" **–** David Moss, **Care Daily**

- **Monitoring care helps avert crises due to dementia, fall risk or wanderers.** The stories of individuals wandering away from (or around in) a senior living community are famous. They contribute to a reputation collapse that may be irredeemable and lead to lawsuits or major business issues. Since the emergence of those scandals, tracking of individuals with dementia has begun to evolve towards more use of wearables or in-room sensors – beyond doors clanging shut and alarms. While in-room and more state-of-the art on-body sensors have improved and declined in cost and easier implementation, the senior living industry has not yet fully embraced them. But change may be underway.

  "*Note that even in senior living, 94% of falls go unwitnessed. Caregivers and clinicians need better tools to understand the root cause of these falls.*" – Tom Bang, **SafelyYou**

Why sensors help care staff deliver more effective care

The time is right for examining the future of sensor technologies which can help optimize the care workforce and processes. Given that they can be helpful for detecting and averting crises, what will push organizations into further evaluation and possible deployment?

The crisis of care staffing – we know there isn't enough. Sixty-one percent of nursing homes have limited admissions due to staff shortages. Some worry that the industry cannot recover. Since January of 2020, 400,000 nursing home and assisted living workers have quit. The shortage is keeping people in the hospital for longer than their health status warrants. And the shortage of home care aides is only going to worsen over the next decade. Furthermore, both CDC and AARP data shows a shortfall in the supply of family and informal caregivers. In fact, family caregivers will be increasingly likely to be paid for the care they provide.

Can sensors also have an impact on staffing challenges? You know the long hall – it's where the hospital room or apartment of your family member was situated – all the way at the end. Never mind that the location was isolating for the resident or patient. Consider the staff's daily and nightly workload of check-in walks. Now think about appropriately placed sensor technologies – motion sensors, radio waves, localized AI cameras, near or on-body movement detection technologies. All are designed to monitor activity or its absence. Mrs. Smith is asleep and comfortable, but Mr. Jones is pacing around the room and tries to get outside. And nursing home residents in wheelchairs need assistance in repositioning.

"A person trips, falls, is hospitalized. They can't go home due to decreased mobility or lack of supervision. Let's send them home with a tech package and treat them there."**–** Ran Manor**, Baycrest**

Improved workflow for staff and better communication with families. Once it was viewed as adequate to respond to family calls by asserting without any detail that 'it seems your mother had a pretty good night.' Those days should be over. Using sensors and sharing the data with family members can reassure them that the facilities staff or home care workers are doing the job **AND** that a family member is okay.

"The overnight wellbeing of the care recipient is important. With sensor technology worn by individuals and staff, there is data for shift turnover – noting what happened on the prior shift." **–** Adam Sobol, **CareBand**

Noting condition and movement can enable targeted staff intervention. The combination of monitoring and precisely targeted intervention, especially at night, could optimize staff workload – alerting and sending them where help is needed, instead of the traditional long-hall check-ins involving opening doors and disturbing sleep. And sensor technology can help family members whose aging relatives may be living alone and at some risk. But if sensors could, as one interviewee noted, save a few hours of time here and there, that can add up. Risk is reduced with improved safety of care recipients who may be alone for hours at a time. And appropriately

managed sensors could help delay the move to a higher level of care that neither the resident, staff, or family wants.

Analytics enable understanding of how a particular community is performing. Today there are still communities that flip a door indicator when a resident leaves the unit for breakfast. However, they could have had an incident (such as a fall) in the room that had happened hours before the doors are checked. With sensors in the apartment, automated check-ins at night and in the morning are feasible – and their labor savings can be calculated over time.

"Every day, a caregiver goes into a facility and takes notes about the situation – but instead of check-ins of 57 apartments every three hours, analytics about what is happening are generated automatically. They will save the equivalent of at least one FTE, plus help delay the move from Independent Living to Assisted Living." – Ashutosh Saxena**, Caspar.ai**

Categories and examples of sensors in use today

Today's sensor market includes a broad variety of sensors and behavior markers that can trigger action or update data for subsequent analytics and advice. It is a particularly appropriate time for evaluating them in the labor-constrained care markets. Limiting in-person check-ins in communities to those in actual need could free up existing staff. And for home care operators, it is feasible today to reduce trips (or shift duration) for individual homes, but still stay in touch and fully aware of the wellbeing of the care recipient or older adult as they age (see **Figure 6**). The types of sensors fit into a process to identify and respond to change, including:

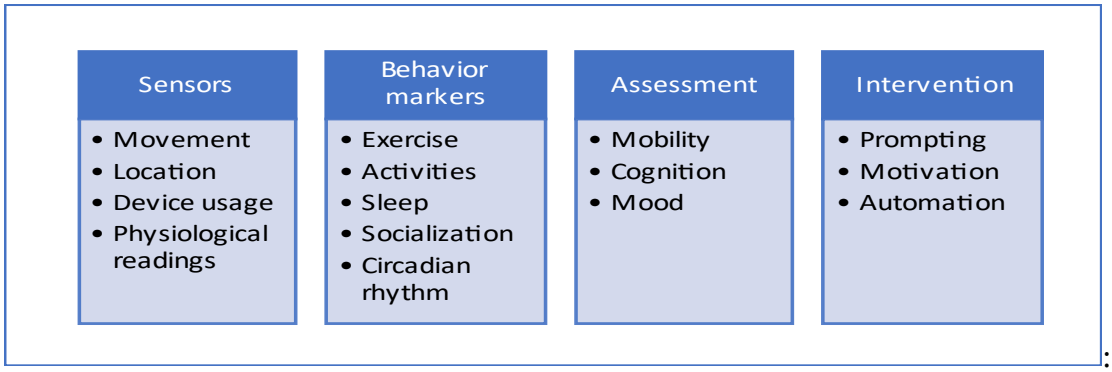

Figure 6 The sensor-based process to support aging **Source: NIH**

Environmental. Today devices can be placed in the home that can detect environmental changes – including air quality, monitor and set temperature, detect changes in humidity (a signal of water in the home), light changes, or listening for sounds in the environment that may signal a problem.

"If there is a loud sound – we can tell you and send the caregiver a clip of the sound if it is something of concern." – Fereydoun Taslimi, **SensorsCall**

Safety. Sensors can be used to detect falls, departure or entrance to a room, a building, or a defined off-limits region. And the lowest cost, such as motion-activated night lights, can be bathroom trip life savers. Other sensors can be used to detect stove usage, running water, or notable changes in temperature. Most sensors are placed or mounted somewhere in a room. But with the recent introduction of Wi-Fi sensing, as with Origin Wireless, the visual perspective can be expanded.

"Radar, passive infrared sensors, and cameras have a limited field of view – a cone of coverage. Wi-Fi changes the game – one access point sees through walls." – Dan Bugos, **Origin Wireless**

Health. Motion sensors can note bathroom trips, indications of a possible UTI. They can also detect heartbeat using LiDAR. Wheelchair-bound individuals can avert pressure sores through use of a smart wheelchair cushion, track and predict changes in respiration or heart rate, or note other health status changes, such as via a diabetic sensing boot from Sensoria.

"Some products require high cognitive function from the user or check-ins from loved ones and caretakers. But sensors in a smart cushion can detect possibility of uninterrupted pressure or failure modes and alert appropriately and in time." **–** Tim Balz**, Kalogon**

Movement. Sensors can detect lack of motion, or unusual motion in a bathroom through use of a privacy-protecting image or with a wearable to track an individual wanderer. Modifying actual images as a form of privacy protection emerged with research done at the University of Missouri. Wall-or-ceiling mounted radar devices from firms like Vayyar and others helped evolve the concept of fall detection to the next stage.

"We had a person fall in the bathroom – she crawled past the pull cord. The device saw that she was on the ground and got her assistance." – Marc McGrann**, Vayyar**

The barriers to adoption are daunting, but can be overcome

Lack of Wi-Fi in the home or community can lead to Edge AI. Although lack of Wi-Fi continues to be a barrier to robust deployment of technology for older adults, other options have emerged and enable care. These include cellular-based tools like smartphones, 'Edge technology' (analysis of data directly on or near the user versus transmission to the cloud), use of alternative Wi-Fi shared access methods for sensors like Amazon Sidewalk, or use of an onsite server that analyzes events before transmitting an alert.

"Some new approaches require very low bandwidth use of sensors. The data is analyzed at the 'edge', that is on the device itself, rather than transmitted to the cloud for processing." – Deepak Gaddipadi, **VirtuSense**

Appropriate messaging to caregivers and older adults. Instead of the impression many may have that big brother (or sister) is watching and noting every move, messaging of products and services must be placed into the context of helping to improve wellbeing as individuals age. The specific sensing performed seeks an exception to a behavior pattern – which can make a big difference to an older adult who wants to remain in their current home.

"The vast majority of older people and their caregivers have not got a clue as to what smart technologies are about. The next player that will embrace this will do so based on urgency and motivation about dollars lost, overburdened families, and short labor supply." – Stephen Golant**, University of Florida**

Lack of awareness limits utility – **for the old-old, but also for the young-old.** Today, there is a growing population of 12 million solo agers – they live and are alone by choice, some in rural or more remote suburban settings. They may be unwilling to move, especially into congregate communities. But just as the home alarm system has made individuals feel safer, so can sensor-based offerings do the same – especially when deployed while individuals are younger. That could mean in existing homes, but also 55+/active adult communities, newly developed Independent Living communities, and tech-enabled Assisted Living and Skilled Nursing Facility (SNF) properties.

"We need to change the perspective – consider this as a service to help support you as you age. That will be a big shift – a support tool for seniors who are younger." – Amanda Forsyth, **Cognitive Systems**

Privacy and security concerns. Who gets the data – and do they want or will use it? This nascent industry must be sensitive to perceptions of a surveillance culture without any return for the value exchange of personal data. Raw streams of health data or activity monitoring is necessary to populate analytics and prediction of change – but is of little interest (and high administrative burden) to health providers or care organizations. However, alerts about important change can matter a great deal. For example, medication changes for Parkinson's patients may be necessary when detecting changes in stability. But even with appropriate permissions, the recipient' status may change and must be reviewed, a process enabled with sensor input.

"As for analytics and dashboards, people do not want all that data. They want insights." **–** Ajay Gulati**, Kami Vision**

Cost of implementation. Although Covid-19 triggered a groundswell of interest in technology in senior living communities, especially in telehealth, major tech investments (like Wi-Fi in

individual units) are still viewed as a *cost*, not yet seen as a *cost savings* (avoiding move-outs or transitions to higher levels of care). The introduction of the new Matter standard and subsequent vendor adoption may end dependency on in-home Do-It-Yourself (DIY) proprietary tech dependent on multiple hubs and frequent updates (see **Figure 7**).

Figure 7 The Do-It-Yourself Smart Home sensor world

"The Achilles Heel for sensor use is data integration – we need to get away from multiple, siloed systems that gather sensor data to a consolidated approach that contributes directly to personalized delivery of all types of care." – Michael Skaff, **Jewish Senior Living Group**

FUTURE OF SENSORS AND OLDER ADULTS

Standards adoption will simplify deployment of sensors. Within the next five years, tech vendors will likely comply with at least some aspects of the Matter standard. The corporate promoters of the standard claim it is intended to make the vision of the smart home a reality, facilitating easily connected devices (see **Figure 8**). Will that make it easier to use sensors, and therefore make their adoption more appealing? Only when pioneering organizations lead the way and make it so – as some of these companies surely could with their own customer base.

"Big problems often start with little changes. Consider that a robot has sensors on it and can get readings closer to the person. Can that help tell us Mom is starting to limp, or that her activity is gradually declining?" – Mike Dooley, **Labrador Systems**

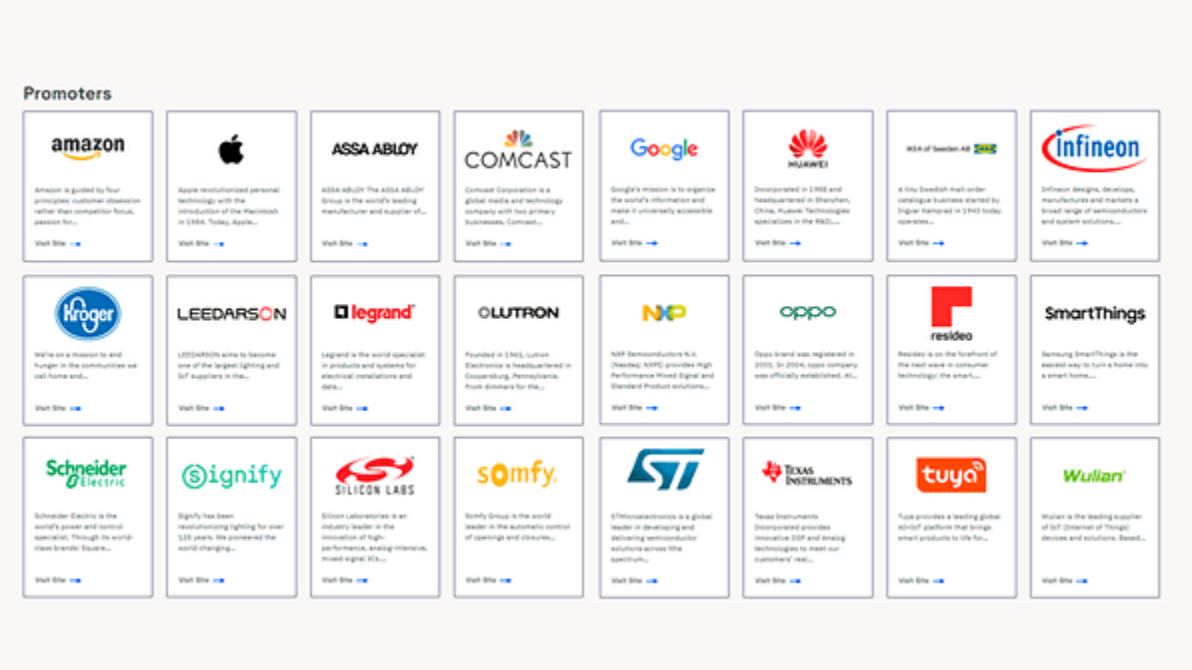

Figure 8 The corporations with stated commitment to the Matter standard

Asynchronous caregiving practices will emerge. Supplementing scarce work staff with sensors will become part of professional care delivery. It's true that sensors will not do the jobs that only hands-on care can deliver. But for night shift monitoring of residents, it seems unimaginable that senior living organizations would continue to cobble together temp workers to fill shifts of hall-walking staffers. It's not likely that home care organizations could continue to turn down contracts due to lack of workers to fill full shifts. Or that family members would continue to stay home to fill gaps in care. Instead, in the future, hands-on care will be optimized and supplemented with tech-enabled monitoring. One option, yet to be tried, is the collaboration among care providers to share the just-right number of workers for the just-right assignments. Perhaps these could be based on time-of-day or location, perhaps based on skill requirement – and analysis of sensor-based information and trends will be enablers.

"We need to offer home care around the clock even when a human care worker is not there. Imagine that I have a Care Pro there from 8-6 pm, but after that I have another Care Pro – technology sensors." **–** Sandy Jen**, Honor**

Cost of care will be rightsized. Because of the combination of sensing technology with in-person assistance, the cost of care will be more closely aligned with what families and organizations should and can afford. As junior staffers are brought on board, they will be shown the career path available to them, including or a new role, Management of Care Technology.

"*We need to attack the mundane and boring tasks – replacing long walks to check on people. Edge AI and sensors can triage requests and direct the most appropriate resources towards needs and optimize care with 'interrupt-driven, just right check-ins." – Ravi Bala, mentor,* ***AgeTech / AssistiveTech startups***

Predictive analytics will be targeted and actionable. Without accurate and useful analytics, sensor technologies are just gadgets. Their history has been primarily as alerting devices – with too many false notifications that are easily ignored. Often incident detection is too late to prevent injury. The key to utility in healthcare and senior care settings will be the automated production of analytics that aid in decision-making – who fell and why? How often? Moving forward, who is likely to fall in senior living, but also in home health and private duty home care settings?

"We will become more and more dependent on devices. We should assume that we will start delegating some care routines to AI engines – reducing the cognitive load of manipulating information. Knowing is better." – Aparna Pujar, **Zemplee**

Data privacy protections will part of sensor solution planning. Armis, a healthcare IoT platform vendor, noted in a white paper that one the five key vulnerabilities in healthcare data security is The Internet of Things. In their research, 63% of healthcare companies reported a security incident related to 'unmanaged IoT devices.' Those evaluating sensor implementations must include device security in their requests for proposals.

"*We generally trust our doctor and nurse to be good stewards of our personal health information, but not the government, pharma, health plans or tech companies. Yet clinicians are overburdened with too much data – they want the exception, but that's not what they generally get."* – Jane Sarasohn-Kahn, **THINK-Health and *Health Populi blog***

Sensor technology will enable moving care from institutions to home. Older adults who live alone do not want to be transferred to a nursing home after hospital discharge. For some individuals, discharge processes in the future will need to incorporate an easy-to-setup sensor package, with monitoring by professionals and family. Private duty and home health agencies are well-positioned to recommend these packages, and their own labor constraints may push them into doing so.

WHY THE FUTURE OF SENSORS MATTERS FOR AGING

Peer into the crystal ball of tech change – look five years and beyond. Given the likelihood of high-speed internet access in nearly all settings, given the sizable wealthy older population, given their housing preferences and location – how will the current environment evolve**?**

Technology ubiquity will transform independence and care. In the post-Covid world, older adults will expect, well into their 80's, to be aging in their own homes. They will expect to leverage now-ubiquitous high-speed Internet (which will be viewed as essential as drinking water.) Senior living organizations will have enterprise-wide Wi-Fi – or be out of business through consolidation or bankruptcy that is the result of low occupancy.

Today's unpaid family caregiver will be reimbursed from sensor-based verification. The care shortages today will be mitigated by a variety of tactics, not limited to, but including payment of family caregivers, validation of their time in the home, as with paid caregivers, performed by arrival-departure sensor tracking.

Standalone technologies will remain on store shelves. Solution providers that thrive will be integrators of sensors, Wi-Fi, voice, and camera technology and beyond, with or without a widely accepted Matter standard. New homes, especially in the booming 55+ markets, will offer tech packages that will enable aging at home. Standalone technologies will be left on the shelves for determined DIY explorers and retail technology service organizations – such as Best Buy Geek Squad or Umbrella (acquired by Angi Home Services as a Task Rabbit for seniors) to assist DIYers.

"Sensor technologies will be more integrated into 3rd party solutions. People need to trust the outcomes of these technologies." – Michael Abcunas, **Stanley Healthcare**

Insurers will discount based on the analytics of sensor use. Sensor technology will increasingly be part of healthcare cost control strategies of providers and insurers. As of 2023, almost have of Medicare recipients will be covered by Medicare Advantage plans that will increasingly incorporate telehealth and Remote Patient Monitoring. Analytics from sensor technologies will be part of the standard solutions that can manage or reduce healthcare costs. Plan prices will reflect those changes, just as smoke alarms are related to homeowner's insurance pricing.

"Medicare Advantage plans will increasingly incorporate sensors and other monitoring into their business." – Howard Teicher, **Medical Guardian**

Sensors will contribute directly to delivery of healthcare

As rural hospitals close and large hospitals struggle with staffing, sensors will play a bigger role in delivery of care, regardless of setting. In-person triage of acute care incidents will be augmented by remote patient and activity monitoring with combinations of smart cameras, health and activity sensors, all used to prevent costly admissions. In addition to today's greater dependency on data transmission to the cloud, more sensing and analysis will occur in the growing number of edge devices. Compare today and contrast it with the future and as always, it has promise (see **Figure 9** and **Figure 10**)!

SENSOR USE TODAY	FIVE YEARS & BEYOND
Used for detection	**Used for prediction**
Periodic review of reports, dashboards	**Automatic delivery of AI-derived insights**
Sensors are added feature	**Sensors are designed into new communities**
Fixed context in sensor data	**AI asks questions to improve insight**
Broadband not 100% available	**Broadband standard in seniors' homes**
Data must be transmitted to cloud	**Data is processed within an edge device**
Staff does check-ins	**System does check-ins**
Home care dependent on labor	**Sensor-enabled 24-hour monitoring**
Continuing Care Retirement Communities	**CCRC without walls and home care**
Hospital to rehab	**Hospital to home**
Wander detection alerts	**Sensor-enabled wander management**
Manufacturer-defined use cases	**User-defined new care services**
Sensing technology as aftermarket install	**Part of new home design, tech is activated**
Privacy and security added	**Privacy and security by design**
Care plans are independent of technology	**Sensor-enhanced care plans**
Fitness, fall detection use cases	**Motion aware (fitness, gait, steadiness)**
Low-frequency biometric spot checks	**Continuous biometrics monitoring**
Sensors focus on incident alerting	**Sensor trends lead to concierge services**
Voice technology is consumer-focused	**Voice is one of multi modes in enterprise**

Figure 9 Sensor usage today, sensor usage in and beyond five years

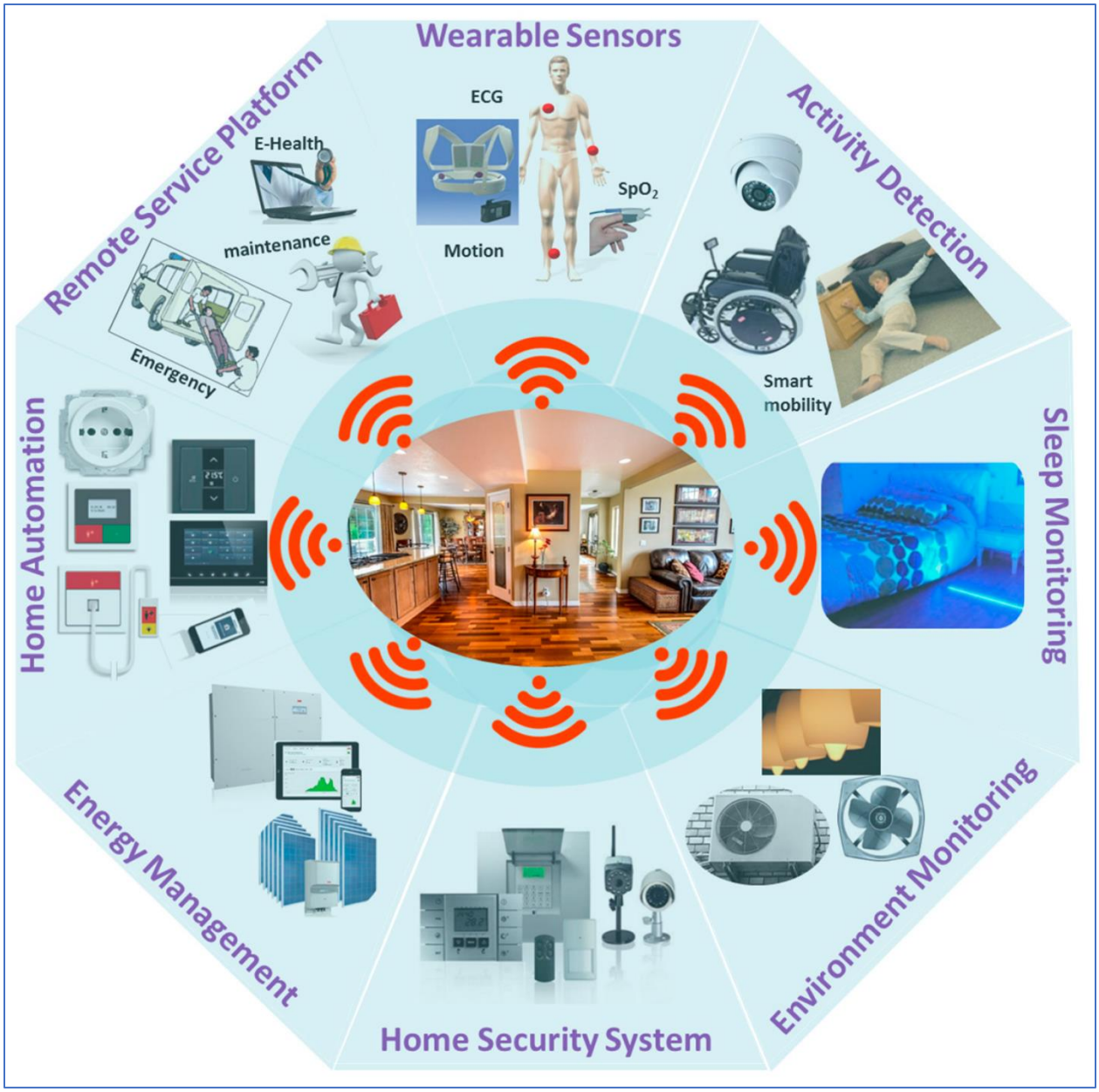

Figure 10 A more coordinated world of sensors for older adults **Source: MDPI**

Firms that provided insights for report – with website link

Baycrest
CareBand
Care Daily
Caregiver Smart Solutions
Caspar.ai
Cognitive Systems
GrandCare Systems
Honor
Jewish Senior Living Group
Kalogon
Kami Vision
Labrador Systems
Stanley Healthcare
StackCare
HealthPopuli
Lamprey Networks Inc
Medical Guardian
Origin Wireless
Parks Associates
Ravi Bala
Safely You
SensorsCall
University of Florida
Upside
VirtuSense
Vayyar
Zemplee

References and Sensor Definitions

Convergence Policy Report

Ambient Assisted Living: A Review of Technologies, Methodologies and Future Perspectives for Healthy Aging of Population

Sensors in Biomedicine and Technology Fact Sheet

What is the Matter Standard: Consumer Reports

What is LiDAR in the home?

What is PIR (Passive Infrared) in the home?

What is Quil, a joint venture of Comcast and Independence Health Group?

What is Edge Computing?

WSJ: The Future of the Computer is Everywhere, All the Time