VUZIX®

WHITE PAPER



The Power of AR Wearables in Healthcare:

Reducing Risk & Improving Outcomes through Telemedicine, Training & 3D Visualization

Digital technology has revolutionized healthcare, creating new ways to meet patient needs and new pathways for medical innovations. The integration of technologies, including augmented reality (AR) and AI, is driving the shift from traditional medicine to precision medicine with enhanced levels of personalized care.

AR wearables like smart glasses have demonstrated success in optimizing hospital resources, reducing costs, and improving patient outcomes. This white paper will explore the use cases and findings from the use of smart glasses in home care, triage, EMT, and surgical applications.

AR in Healthcare Today

AR devices provide users with relevant information on demand. With a hands-free wearable AR device, needed digital information is seamlessly overlaid onto real-world objects and surroundings.

- **Real-time data,** including access to patients' medical records, vitals, and reference material to improve decision-making and optimize patient interactions.
- **3D models,** like anatomical structures, to facilitate training and improve procedure outcomes.
- **"See what I see"** for real-time consultation, collaboration, enhancing learning and improving outcomes.

AR can be accessed on personal devices; however, head-mounted devices like smart glasses are most effective in the healthcare setting, giving clinicians heads-up, hands-free access without diverting focus from the patient.

AR devices often include AI and predictive analytics tools, creating a mixed reality system that optimizes care delivery, while reducing the burden created by imbalances between job demands and available resources, staffing shortages, and skill gaps.

AR Wearables have the power to...

Increase Revenue & Profitability

Hospital costs rose 17.5% without commensurate reimbursement. Smart glasses can:

- Reduce operating room time, saving as much as $100/minute
- Allow for remote consults, increasing billing and speeding diagnosis

Reduce Risk

$17B annual cost of medical errors

Smart glasses can improve access to:

- Remote specialists
- Surgical checklists and other safety improvements
- In-line visualization for fewer errors

Improve Patient Outcomes

By 2025, over **2 million** patients and healthcare workers are expected to use AR for telehealth, including:

- Remote field triage
- House calls to meet rising elder care demands
- Access to specialists in rural and remote areas

The Rising Cost of Care

Healthcare system and hospital costs are increasing across the board, due to:

- Inflation, driving up the cost of medical supplies and equipment.
- Staffing shortages, increasing the reliance on more costly contract labor.
- Growing billing and insurance overhead.
- Declining reimbursement rates as workforce shortages in skilled nursing facilities lead to hospital bottlenecks.

Overall, **hospital expenses rose by 17.5% from 2019-2022**, but reimbursement has not kept pace. From 2019-2022 the rise in hospital expenses more than doubled the increase in Medicare reimbursement for inpatient care[3].

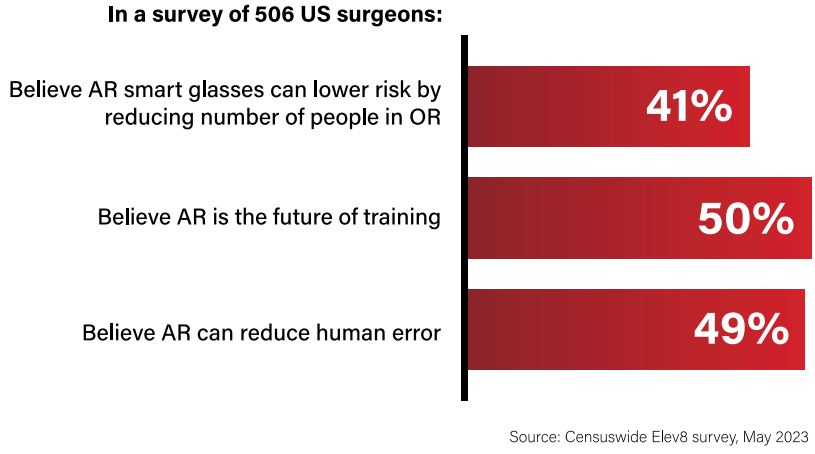
This cost burden poses a significant challenge to the continued operation of many hospitals and clinics, with **136 rural hospitals closing** between 2010-2021[4], another 40% at risk of closing[5], and **16,000** private practices closing in 2020[6].

Augmented reality (AR) technology can help hospitals and other healthcare facilities attain financial sustainability with a more flexible, scalable model of care.

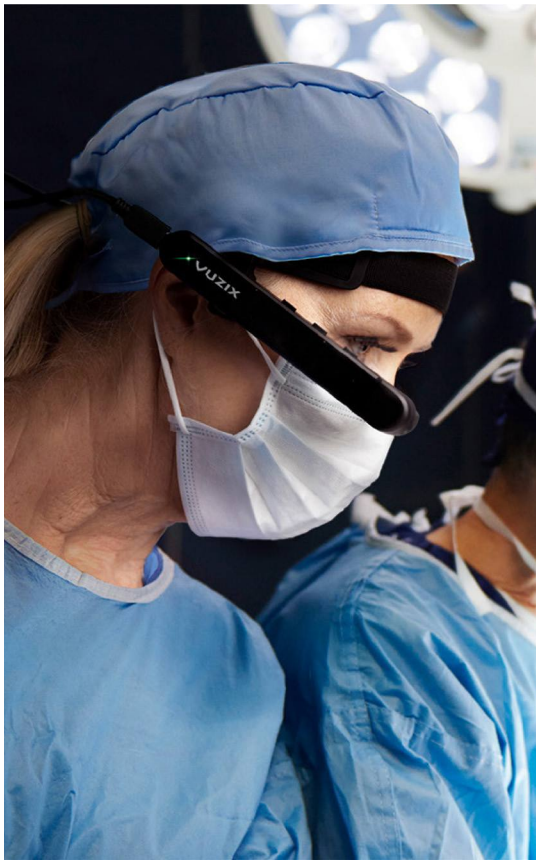
"In healthcare, today's biggest opportunity is capitalizing on the potential of the space in between the real and fully virtual worlds."

— Kaveh Safavi, Senior Managing Director, Accenture Health

Figure 1: AR Smart Glasses Survey of US Surgeons



Source: Censuswide Elev8 survey, May 2023



Use Cases for AR in Healthcare

The use of **augmented reality (AR) in healthcare is growing rapidly and is expected to increase in size from $2.5 billion in 2023 to $11.4 billion by 2030[1].** As healthcare costs rise and the demand for surgical procedures surpasses surgical capacity, wearable AR devices are being used to:

- Perform surgeries.
- Provide telehealth services.
- Train and upskill surgical students and practicing surgeons.



AR in the Operating Room

AR is rapidly emerging as a useful tool for achieving excellence in a variety of surgical specialties, including:

- **Ophthalmology**—Detection of color vision deficiencies, visual field defects, and other vision disorders.
- **Orthopedics**—Fracture care and osteotomies, joint replacement procedures, and orthopedic oncology.
- **Neurosurgery**—Spinal surgery, neuro-oncology, and neurovascular surgery.
- **Microsurgery**—Reconstructive procedures, replantation, and transplantation.

Patient safety is a top priority during and after surgery. **Medical errors are a significant financial burden for hospitals and medical practices, costing over $17 billion annually.** Surgical errors account for 35% of these yearly costs, and 75% of lawsuits against surgeons in the US result from intraoperative error[7]. In addition to the financial impact of errors, these events also are detrimental to reimbursements and reputation.

Over the last few decades, improvements in safety have been made with the implementation of checklists, team-based care models, and measurement tools for safety performance. With predictive modeling and AI capabilities, clinicians can now also easily access and use patient-level data to identify which surgical techniques will best fit a patient based on their medical history, risk factors, and other unique needs.

AR deployment in operating rooms is further driving safety improvements. AR smart glasses provide enhanced visualization and enable advanced image guidance that result in:

- **Increased precision, accuracy, and reproducibility.**
- **Less invasiveness and reduced radiation exposure for patients.**
- **Shortened operating and recovery time.**
- **Reduced complication rates.**
- **Decreased procedural costs.**

Did you know? Vuzix® smart glasses' lightweight ergonomics & long-lasting battery life means they can comfortably be worn during surgery for **16+ hours** straight.

"Vuzix smart glasses represent a lightweight wearable, hands-free solution that delivers high performance on every measure."

— Dr. Nadine Hachach-Haram, Founder & CEO, Proximie

Enhanced Navigation With 3D Visualization

Navigation systems play a key role in the operating room, helping surgeons to:

- Accurately identify anatomical targets.
- Know where they are anatomically and the safest path to the target area.

Identify where and how to best position mechanical elements including screws, prosthetic components, and anchors. Navigation systems that rely on MRI, CT, or other pre-surgical imaging techniques typically display scans on a 2D monitor in the operating room. With this type of system, a surgeon must mentally transform the 2D image into 3D and then project this envisioned 3D image onto the patient.

In contrast, AR smart glasses enable a surgeon to access 3D images and interact with the image in a more natural and immersive format that minimizes awkward manipulations on a monitor. This improved navigation enables surgeons to:

- **Maximize their time** with enhanced situational awareness and for faster surgical planning.
- **Maintain their patient-centered focus** by reducing the cognitive load needed for utilizing visual information.



Improved Surgical Site Focus

When surgeons must alternate their attention between the surgical site and a monitor to access needed images and information, it can negatively impact hand-eye coordination and elevate the risk of error. With augmented reality (AR) smart glasses, 3D images are located within a surgeon's field of view or are projected directly onto the patient, enabling the surgeon to remain focused on the surgical site.

To further minimize distractions and improve patient outcomes, surgeons using AR wearables can:

- **Increase precision and reduce surgical errors** by selectively highlighting key anatomical landmarks and structures that must be avoided.
- **Control their visual field** with the ability to adjust opacity—for example, turning off all displayed images and becoming fully opaque during an emergency.
- **Maintain aseptic protocols and surgical workflow** with hands-free, voice-activated control.
- **Keep their focus and hands on the patient** while monitoring vital signs.
- **Seamlessly communicate and collaborate with their team and remote experts** with shared, live intraoperative video, free of viewing obstructions for improved patient care.

"Having the Vuzix glasses gives you the truth. Meaning that you can intend to put a screw at a 12° angle, and you can think you put a screw at a 12° angle…to know right then as you're about to put the drill down, that's not it, and you make an adjustment, that's immediate feedback for excellence."

— Dr. Wes Cox, MD, Orthopaedic Shoulder & Elbow Surgeon and Section Chief at UAMS Orthopaedics & Sports Medicine

AR Wearables: Addressing the Backlog in Patient Care

Telemedicine

The COVID-19 pandemic spurred a digital transformation in medicine. With suddenly limited options for in-person healthcare visits, medical providers rapidly pivoted to the use of telehealth solutions to provide care—telehealth appointments increased by 2013% by June 2020[6]. This trend is expected to continue, and **by 2025, over 2 million patients and healthcare workers are expected to be using AR for telehealth purposes[8]**.

Due to an aging population, the need for medical care and surgical procedures is also increasing. The number of adults age 85 and older is expected to quadruple by 2050, resulting in growing demand for in-home doctor visits as well. At the same time, rural hospitals are closing



Vuzix M400™ smart glasses

- Lightest in class
- Hot-swappable battery and backup power for even the longest surgeries
- See-through waveguide-based display for a clear, unobscured visual field

Case Study: Scaling Specialist Expertise With AR

Vuzix M400 smart glasses were used during rounds on neuro-critical patients at the University Malaya Specialist Centre to reduce the number of medical providers required.

A virtual ward round was first done by a remote specialist with access to real-time information from a resident wearing the smart glasses. Next, a physical ward round was performed by a different resident/specialist pair on the same patient.

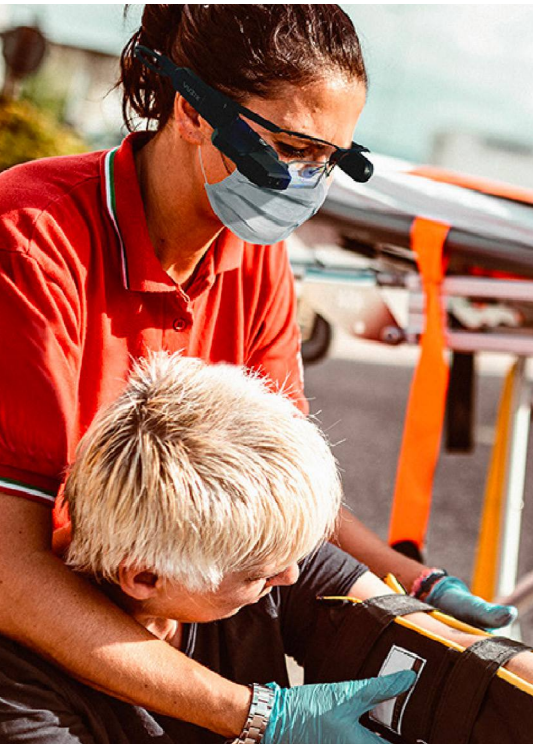
10-paired ward rounds were conducted on 103 patients and treatment plans were compared to measure intra-rater reliability. **9 out of 10** showed good to excellent internal consistency, 1 acceptable internal consistency, with high rates of user acceptance and satisfaction.

at a record pace, and the number of doctors and surgeons entering practice is lagging—a physician shortage of up to 124,000 doctors is expected by 2034[9], and by 2030, there will be 19,184 fewer general surgeons than needed[8]. **Augmented reality (AR) technology will play a key role in meeting the need for medical and surgical services by providing a flexible care model that scales existing expertise and boosts practitioner efficiency—maximizing case volumes while maintaining safety and results.**

Recent studies on the use of AR for remote evaluation of patients including remote triage, postoperative wound assessments, and hospital rounding highlight the benefits and feasibility of utilizing AR for expanded telemedicine capabilities (Figure 2).

Figure 2: Study Findings—
The Benefits of AR Use in Remote Patient Care

Remote Triage	Remote Postoperative Wound Assessment	Remote Hospital Rounding
• High assessment reliability • High assessment accuracy	• High assessment reliability • Fewer unplanned surgical revisions • Fewer hospital admissions for wound infection	• Improvements in quality of patient care and care team decision making • Reduction in time exposed to harm for staff caring for COVID-19 patients • Reduction in the amount of PPE used



AR in Patient Evaluation and Education

AR, particularly when used in combination with IoT-connected patient sensors, offers medical practitioners the opportunity to deliver real-time remote care that extends beyond the limits of videoconferencing programs currently in use by many hospitals and clinics. At the same time, the use of AR for in-person acute and ambulatory care is also growing. When used for either in-person or remote patient care, AR wearables optimize patient interactions, allowing clinicians to:

- **Instantly access needed information**, including patient medical history, medication lists, and vital signs.
- **Maintain patient focus and ensure patient safety with hands-free,** head-up access to medical documentation and expertise.
- **Easily connect with remote team members and experts** for coordinated, quality care.
- **Provide patients with contextual, interactive educational resources,** increasing their understanding of health conditions, procedures, and care plans.

Did you know? Vuzix smart glasses are HIPAA-compliant and IP67 rated.

Training and Upskilling Improvements with AR

In response to scientific and technological advancements and shifts in societal expectations, medical education has experienced extensive change. Patient safety is now at the forefront throughout the medical education process, and a new generation of medical students who were born into a digital world expect technology to be integrated into all aspects of their education. Augmented reality (AR) wearable devices play an important role in this technologically-enhanced learning process by improving access to rich and immersive information during medical training and supporting collaboration and upskilling with remote experts during telesurgery mentoring.

Solutions Designed by Healthcare Experts

Healthcare is not a game, but most AR technology is designed for gamers, first and foremost. Vuzix and its software partners have designed a suite of AR solutions to meet the specific needs of healthcare:

Privacy
GDPR and HIPAA compliant software and hardware. AI functionality that blurs faces to protect patient privacy. ISO 27001 compliant software for cyber security.

Connectivity
Operating rooms and remote clinics face wifi connectivity challenges. Our software partners offer teleco solutions to ensure connectivity in the field or OR.

Anti-Fatigue
Lightest smart glasses in class for reduced neck strain. Battery life and power backup allow for up 16+ hours in surgery.



Medical Training

The traditional training model of supervised procedures on patients is facing numerous challenges due to:

- More complex surgical procedures.
- Strict work hour limits for residents.
- Growing ethical concerns regarding the extent of trainees' roles in the provision of patient care.
- An increasingly litigious legal environment.

Training residents is expensive, with **hospitals spending over $183,000 per year** in direct and indirect training costs per resident. Smart glasses can improve patient safety and expand training opportunities and efficiencies.

In response to these challenges, hospitals are incorporating AR devices into their training programs to provide expanded opportunities for skill attainment. AR offers efficient learning opportunities that maintain patient safety while also gaining the benefits that come from hands-on learning—**experiential learning using tools like AR can boost learning quality and retention by as much as 75%**[10]. AR devices provide trainees with access to:

- **Immersive learning content** including 3D animated and interactive anatomical structures and maps for advanced data visualization and simulation learning. AR apps can display structures in motion and allow students to "remove" bones or other parts, enabling them to study from all angles and understand how various structures function.
- **The surgeon's operating view** with recorded and real-time streaming of surgical procedures from the surgeon's perspective, providing the ideal view for learning.

As a result, the demand for AR training in healthcare is high—**60% of medical professionals indicate they are interested in using AR devices for learning and 78% state that AR technology improves training (Figure 3).**

Figure 3: AR in Medical Training—
Survey of Medical Professionals



Source: Market Research Future

Telesurgery Mentoring

Telesurgery mentoring with Augmented reality (AR) smart glasses is being used by hospitals to enhance learning and surgical outcomes. Over the last two decades, the increasing complexity of surgical procedures and continuous advancements in surgical techniques often require both surgical trainees and seasoned surgeons to learn new skills and techniques. While these advancements can offer several benefits to patients, including less pain and faster healing, the learning curve involved can negatively impact patient outcomes and complication rates if a practitioner does not receive adequate training and guidance. AR-supported guidance is also beneficial when devices or implants are used that require input from an industry representative during the procedure.

AR-supported telesurgery mentoring provides several advantages to surgical trainees and practicing surgeons including:

- **Cost-effective access to hard-to-reach experts** who can remotely 'scrub-in' from widespread geographical locations and see exactly what the surgeon is seeing.
- **Improved patient outcomes** through convenient access to remote expertise even when a procedure is unplanned and time-critical.
- **Rapid acquisition of new skills** from collaborative teaching of intricate surgical procedures with the ability for the teaching surgeon to display their hands, tools, and digital markers and notes in the user's view and "see-what-I-see" communication that enables optimal viewing even during minimally invasive procedures that have a decreased viewing field.

In a 2022 study[11] comparing the use of AR to video conferencing for telementoring in skin cancer surgery, AR-supported telementoring yielded several benefits including:

- **16% increase** in accuracy.
- **54% reduction** in operating time.

While telementoring can be conducted using real-time video conferencing, telementoring using a wearable AR device offers several advantages:

- **Access to both visual and verbal guidance.** Video conferencing systems that support only verbal guidance put a demand on the advising clinician's verbal skills and are difficult to use when language differences exist. Virtually label and draw right on the patient's anatomy to provide effective guidance on incision points, device placement, and steps in real time.
- **Reduced shift of attention**. Video conferencing-based systems display images and instructions on a monitor outside the clinician's visual field, requiring the surgeon to look at the monitor and then look back again at the surgical area to map the instructions to the surgical site, which can result in errors.
- **Decreased surgery time and fewer errors.** Real-time, hands-free access to verbal and visual guidance, with visual aids readily accessible on the same optical path as the surgical site, means surgeries can be performed faster and more safely.

"[Vuzix] glasses allow you to have a transparent display, allowing the surgeon that is training this person to see their point-of-view. This, I would say, is the future of surgical training."

— Dr. Ahmed Ghazi, MD, FEBU, MHPE, Associate Professor of Urology, University of Rochester



Case Study: Saving Lives With AR Surgery Assist Program

Ohana One, a California-based non-profit, partnered with Vuzix to create the **Surgical Sight Smart Glasses program**, providing high-quality, individualized remote surgical training to low- and middle-income countries where surgeons lack resources and mentors for training.

The program works in six different specialty areas: Plastics and Reconstructive, General and Colorectal, Neurology, Urology, OBGYN, and Orthopedic. The results speak for themselves:

- **95** surgeons
- **41** countries with **4.43 billion** residents
- **1,664+** life-saving procedures



Key Takeaways

The shift to precision medicine is emerging. The expectation for personalized, proactive treatment is growing, while, at the same time, costs are rising, and the pool of experienced medical professionals is shrinking. To navigate these challenges, healthcare organizations are making strategic investments in technological advancements like Augmented reality (AR).

With AR deployment, healthcare providers can:

- Improve surgical outcomes, while decreasing procedure costs.
- Increase patient satisfaction with enhanced patient-centered care.
- Quickly train and upskill medical talent and scale expertise in a cost-effective way.

Combining medical expertise with the power of AR wearable technology opens new opportunities for maximizing available resources and improving bottom line results while providing responsive, high-quality patient care.

Vuzix offers a comprehensive line of smart glasses and software solutions to meet your needs.

VUZIX BLADE®



VUZIX M400™



VUZIX M4000™



Request a Demo

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