[Skip to content](https://chatgpt.com/g/g-p-675d641377cc8191a73e9d007f71f8e0-cpr-assist-glove/c/687cdbdb-6ea4-8007-8120-4556e0f5b049" \l "main)

**Chat history**

**You said:**

now you have a genaral idea of what my master thesis is about. Can you search for similar tesis and tell me what is the best template to follow for the written part?

**ChatGPT said:**

Given your CPR Assist Glove project — a hardware-software system that includes embedded electronics, BLE communication, a mobile app with real-time CPR guidance and training, plus a backend — the best template for your Master’s thesis should align with **engineering or applied computer science standards**. Here’s a breakdown of what works best for your multidisciplinary project (biomedical + software + embedded systems):

**✅ Recommended Thesis Template Structure**

Based on similar technical and biomedical engineering theses, this format would be optimal:

**1. Cover Page**

* Title
* Name
* Program & Department
* University
* Date
* Supervisor(s)

**2. Abstract**

* Summarize the purpose, methods, results, and significance (max 300 words).

**3. Keywords**

* e.g., CPR, wearable systems, biomedical sensors, ESP32, BLE, real-time feedback, emergency response

**4. Table of Contents**

* Auto-generated in LaTeX.

**5. List of Figures & Tables**

* Especially useful due to your schematics and graphs.

**6. Abbreviations / Symbols (optional)**

**7. 1. Introduction**

* Background on CPR problems
* Motivation
* Goal of the thesis
* Overview of your solution (wearable glove + app)
* Research questions or hypotheses

**8. 2. Related Work / Literature Review**

* Existing CPR feedback systems
* Medical standards (e.g. AHA or ERC CPR guidelines)
* Wearables in health monitoring
* BLE-enabled devices for training/emergency

**9. 3. System Architecture**

* Overall block diagram
* Sensor selection rationale (FSR, accelerometer, MAX30102, TMP117, etc.)
* Glove schematic and hardware choices (use CPR\_Assist schematic.pdf)
* Power system: PowerBoost 1000C
* Data acquisition and BLE encryption strategy

**10. 4. Software and Firmware Design**

* Arduino code structure: sensor reading, BLE transmission
* Encryption mechanism (AES-128 ECB)
* Packet structure and BLE data splitting
* Flutter app: architecture (Live screen, Training mode, AED map, etc.)
* Backend API (refer to index.js, auth.js, etc.)
* Communication protocols (ESP <-> App <-> Backend)

**11. 5. Implementation**

* Prototyping steps
* PCB/glove integration
* App screenshots and interface
* Server deployment (e.g., Railway or Heroku)
* Testing BLE packets and decryption

**12. 6. Evaluation and Results**

* Testing scenarios (training vs emergency)
* Accuracy of sensor readings
* Latency of feedback
* BLE communication reliability
* Backend performance
* User testing if available

**13. 7. Discussion**

* Strengths
* Limitations (e.g., battery life, network dependency)
* User fatigue analysis
* Real-world challenges (e.g., panic scenarios, hand placement)

**14. 8. Future Work**

* AED integration via NFC?
* Integration with national EMS?
* Offline mode
* Improved fatigue detection via HRV
* Wider trials with first responders

**15. 9. Conclusion**

* What you built
* What impact it has
* Where it can go next

**16. References**

* APA style as requested
* Cite medical CPR standards, relevant BLE/device papers, Flutter packages, etc.

**17. Appendices**

* Full code listing if required
* Full BoM (use final\_Final BoM\_CPR Glove.xlsx)
* Additional schematics
* Ethics approval if human testing

**🔧 Best Template to Use**

You should use a **LaTeX template for a technical master thesis**. Recommended options:

1. **Overleaf: "Master Thesis (Engineering - APA)"** – Includes APA style citations, clean layout.
2. **Aristotle University Thesis Template** – Check your department’s official repository, or I can help you adapt an Overleaf one to match your university's formatting rules (cover page, fonts, logo etc.).
3. **Alternative**: Start with classicthesis and customize the chapter flow above.

Would you like me to:

* Set up a custom LaTeX template for you based on this format?
* Help write specific sections (intro, abstract, related work, etc.)?
* Generate diagrams for your system architecture?

Let me know how you'd like to proceed.

**You said:**

how long should it become? and what should i wriet in thse: 9. 3. System Architecture Overall block diagram Sensor selection rationale (FSR, accelerometer, MAX30102, TMP117, etc.) Glove schematic and hardware choices (use CPR\_Assist schematic.pdf) Power system: PowerBoost 1000C Data acquisition and BLE encryption strategy 10. 4. Software and Firmware Design Arduino code structure: sensor reading, BLE transmission Encryption mechanism (AES-128 ECB) Packet structure and BLE data splitting Flutter app: architecture (Live screen, Training mode, AED map, etc.) Backend API (refer to index.js, auth.js, etc.) Communication protocols (ESP <-> App <-> Backend) 11. 5. Implementation Prototyping steps PCB/glove integration App screenshots and interface Server deployment (e.g., Railway or Heroku) Testing BLE packets and decryption just say i used this and this?

**ChatGPT said:**

Great questions. Here's a **critical and complete breakdown** of:

**✅ Thesis Length Expectation**

For a **Master’s thesis in engineering** (especially technical/biomedical like yours), the typical length is:

* **Total**: **60–80 pages**, including figures and appendices.
* **Chapters 3–5 (System, Software, Implementation)**: around **20–30 pages total**.
  + System Architecture: ~7–10 pages
  + Software/Firmware Design: ~7–10 pages
  + Implementation: ~6–10 pages

**🧠 What to Write in Each Section**

**🔷 3. System Architecture**

**Goal**: Explain the hardware system and your design decisions.

**🖼️ Overall Block Diagram**

* Create a **diagram** showing:
* Sensors → ESP32 → BLE → Flutter App → Backend (PostgreSQL + Express)
* ↑ ↓
* Feedback (LEDs, vibration, speaker)
* Show both data **flow** and **control/feedback** loops.

**🧪 Sensor Selection Rationale**

Write critically about *why* you chose each:

* **FSR (FlexiForce A401)** – for force → depth approximation.
  + Thin, embeddable, widely used in CPR research.
* **Accelerometer (LSM6DSOX)** – for movement/depth & hand angle.
  + 6-DoF IMU, small, with low noise and good sampling rate.
* **MAX30102 (x2)** – optical pulse and temp sensor.
  + Used on user and patient to measure HR and fatigue.
* **TMP117 (x2)** – high-precision temperature sensor.
  + Measures surface temp precisely, including gloves/fatigue.

→ Add a **table** comparing each sensor against alternatives.

**🧤 Glove Schematic and Hardware Choices**

* Use the uploaded CPR\_Assist schematic.pdf.
* Describe key connections:
  + FSR → analog pin
  + I2C bus for sensors
  + GPIO for LEDs, speaker, vibration
* Why ESP32-DevKitC-32UE:
  + Built-in BLE
  + Plenty of GPIO
  + Small enough for glove form factor

**🔋 Power System: PowerBoost 1000C**

* Explain why you use this:
  + LiPo charging and BMS
  + 5V boost output
  + Can charge while powering glove
* Mention battery specs and usage time.

**🔒 Data Acquisition and BLE Encryption**

* Real-time sensor readings in loop.
* 48-byte AES-128 ECB encrypted packets (explain why you chose **ECB** and its tradeoffs — simplicity vs security).
* Packets split into 3×20 byte BLE packets (due to BLE MTU limits).

**🔷 4. Software and Firmware Design**

**Goal**: Explain software layers — firmware, mobile app, backend.

**⚙️ Arduino Code Structure**

* Mention CPR\_Glove.ino.
* Describe flow:
* loop():
* - Read sensors
* - Process data
* - Encrypt
* - Split and send via BLE
* - Listen for session commands
* Show key logic in a flowchart.

**🔐 Encryption Mechanism (AES-128 ECB)**

* Mention mbedtls or AESLib usage.
* Padding method.
* Why 48 bytes (align with AES block size).
* Security tradeoffs (no IV in ECB — easier but less secure).

**📦 Packet Structure**

* How you pack float/int values into the buffer.
* Add packet structure diagram:
* [FSR][AccelX][AccelY][AccelZ][HR\_user][Temp\_user]...
* → float or int, converted to 4-byte chunks.
* 48-byte encrypted → 3 packets of 20 bytes (with 2-byte headers).

**📱 Flutter App Architecture**

* Overview of app screens:
  + LiveCPRScreen – Real-time feedback
  + TrainingScreen – Stats & gamification
  + AEDMapDisplay – Nearby AEDs
* Use a **screenshot or wireframe**
* Mention BLE library: flutter\_blue\_plus, and decryption in decryption.dart.

**🌐 Backend API**

* Reference index.js, auth.js, session.js.
* Built in **Express + PostgreSQL**.
* Show routes:
  + /auth/login
  + /sessions/summary
  + /aed/locations
* Mention middleware, validation, token auth.

**🔄 Communication Protocols**

* Show how:
* ESP32 <—> BLE <—> Flutter App <—> HTTP <—> Backend
* Mention BLE packet arrival → app decrypts → UI updates & backend saves.

**🔷 5. Implementation**

**Goal**: Describe how you actually built and tested the system.

**🛠️ Prototyping Steps**

* Glove sewing + sensor positioning.
* Breadboard → PCB or perfboard.
* Power testing.

**🧤 PCB/Glove Integration**

* Describe how the hardware was secured in glove.
* Add real **photos** or CAD design if available.
* Emphasize usability (comfort, weight, wire routing).

**📱 App Screenshots and Interface**

* Add screenshots of:
  + Real-time feedback screen
  + AED map
  + Training history
* Describe visual feedback (LEDs, graphs, etc.).

**☁️ Server Deployment**

* Mention Railway or Heroku or other service used.
* Use .env for config.
* Deployment process (npm, pm2, etc.).

**✅ Testing BLE and Decryption**

* Mention how you simulated packets.
* Show logs of BLE packets.
* Describe how you tested:
  + BLE range
  + Session data integrity
  + Packet loss
  + Decryption correctness

**❗ Summary**

You shouldn’t just say “I used this and that” — instead:

* Explain *why* you chose each method/component.
* Include diagrams, tables, and screenshots.
* Be **technical but clear**: assume your reader understands basic electronics and code, but not your specific implementation.

If you'd like, I can:

* Help you draft specific subsections
* Generate diagrams for block flow or packet structure
* Build a LaTeX thesis file with this structure

Let me know what you'd like next.

**You said:**

lets start from the beginning. Help me step by step to start writing. I have an overleaf file: \documentclass[12pt,a4paper]{report} \usepackage[utf8]{inputenc} \usepackage[english]{babel} \usepackage{amsmath, amssymb} \usepackage{graphicx} \usepackage{float} \usepackage{hyperref} \usepackage{natbib} \usepackage{geometry} \usepackage{titlesec} \usepackage{fancyhdr} \usepackage{setspace} \usepackage{listings} \usepackage{color} \geometry{margin=1in} \definecolor{codegray}{rgb}{0.5,0.5,0.5} \definecolor{backcolour}{rgb}{0.95,0.95,0.92} \lstdefinestyle{mystyle}{ backgroundcolor=\color{backcolour}, commentstyle=\color{codegray}, keywordstyle=\color{blue}, numberstyle=\tiny\color{gray}, stringstyle=\color{red}, basicstyle=\ttfamily\footnotesize, breakatwhitespace=false, breaklines=true, captionpos=b, keepspaces=true, numbers=left, numbersep=5pt, showspaces=false, showstringspaces=false, showtabs=false, tabsize=2 } \lstset{style=mystyle} \title{CPR Assist Glove:\\A Real-Time Feedback and Emergency Response System} \author{Evanthia Rouka\\Master's Thesis} \date{Aristotle University of Thessaloniki\\School of Electrical and Computer Engineering\\June 2025} \begin{document} \maketitle \pagenumbering{roman} \tableofcontents \listoffigures \listoftables \newpage \pagenumbering{arabic} \setstretch{1.5} \chapter{Introduction} \input{chapters/introduction.tex} \chapter{Background and Related Work} \input{chapters/background.tex} \chapter{System Overview} \input{chapters/system\_overview.tex} \chapter{Hardware Design} \input{chapters/hardware.tex} \chapter{Software Implementation} \input{chapters/software.tex} \chapter{AED System and Emergency Mode} \input{chapters/aed\_emergency.tex} \chapter{Training Mode and Performance Tracking} \input{chapters/training\_mode.tex} \chapter{Testing and Evaluation} \input{chapters/testing.tex} \chapter{Conclusion and Future Work} \input{chapters/conclusion.tex} \bibliographystyle{apa} \bibliography{references} \appendix \chapter{Appendix} Full Arduino code Flutter widget breakdown API specs Additional graphs, logs, tests \end{document} help me change it and make it better and lets start with the first part. The introduction

**ChatGPT said:**

Great — I’ve optimized your thesis structure slightly for clarity, flow, and standard naming, including:

* Clearer chapter titles
* Better title formatting
* Consistent terminology

**✅ Now, Let’s Start with the Introduction**

Here’s how your chapters/introduction.tex should be structured:

**🔹 Structure of the Introduction**

\chapter{Introduction} \section{Motivation} % Why CPR quality matters, global statistics, and survival impact. \section{Problem Statement} % The core problem: bystanders often perform CPR incorrectly. % Lack of real-time feedback tools accessible to non-professionals. \section{Project Objectives} % What this project aims to solve: real-time, wearable feedback system. % Quick data visualization and emergency communication. \section{Contributions} % What this thesis delivers: % - A wearable glove with sensors and feedback mechanisms % - An Android/iOS app with live CPR support and AED integration % - A backend for session tracking and user management \section{Thesis Outline} % Brief summary of each chapter

Would you like me to generate the actual written content for the Introduction based on this structure next?

**You said:**

yes start writing the introduction. Write it correctly based on all the info you know. Use formal tone but not too much

**ChatGPT said:**

✅ The Introduction is now written and includes the following structured sections:

1. **Motivation** — CPR importance and common performance issues
2. **Problem Statement** — The need for accessible, real-time CPR guidance
3. **Project Objectives** — What the CPR Assist Glove does and how
4. **Contributions** — Your work across hardware, firmware, mobile, and backend
5. **Thesis Outline** — Chapter-by-chapter summary

Would you like to proceed with Chapter 2 next (Background and Related Work), or do you want to insert any figures or citations into the introduction first?

**You said:**

\section\*{Introduction} Purpose: Frame the context, the problem, and your contribution. Background context (e.g. survival rates, importance of CPR quality) Problem Statement: Why existing CPR methods are lacking Research Goals: Improve CPR performance via wearable feedback and AED coordination Proposed Solution Summary: Glove + mobile app + backend + AED notification Thesis Structure: Brief overview of each chapter \chapter{Introduction} \section{Motivation} Cardiac arrest is a leading cause of sudden death worldwide, with survival rates highly dependent on the quality and timeliness of cardiopulmonary resuscitation (CPR) performed by bystanders. Studies show that early and high-quality CPR can double or even triple the chances of survival. Despite its importance, many people either hesitate to perform CPR or fail to apply it correctly, particularly in stressful emergency situations. Common issues include incorrect compression depth, insufficient frequency, and improper hand positioning. Furthermore, fatigue sets in quickly, reducing CPR effectiveness over time. These challenges underline the need for tools that provide real-time feedback and support to improve CPR performance during emergencies. \section{Problem Statement} Although CPR is a critical life-saving skill, most bystanders lack access to tools that can guide and support them in real-time. Existing CPR feedback devices are often expensive, bulky, and primarily used in professional or training environments. There is a significant gap in accessible, wearable solutions that offer intuitive feedback and integrate seamlessly with emergency response systems. Additionally, even trained individuals can struggle with maintaining correct technique or identifying the nearest Automated External Defibrillator (AED) in a time-sensitive scenario. This thesis addresses the lack of affordable, real-time, and connected CPR assistance solutions that could enhance both training and real-life intervention. \section{Project Objectives} This project presents the design and development of the CPR Assist Glove: a smart, sensor-equipped wearable device that offers real-time feedback during CPR. The glove integrates multiple sensors to measure compression depth, frequency, hand angle, and signs of rescuer fatigue. It wirelessly transmits this data via Bluetooth Low Energy (BLE) to a mobile application built with Flutter, which visualizes performance, provides live audio and visual feedback, and manages emergency features. The system also includes an emergency response mode that can notify nearby responders, share the user's location, and display directions to the nearest AED. Additionally, the glove features a training mode that tracks user performance and allows retrospective analysis through a connected backend server. \section{Contributions} The key contributions of this thesis are: \begin{itemize} \item The design and prototyping of a wearable glove system integrating pressure, motion, heart rate, and temperature sensors. \item Development of real-time firmware on the ESP32 microcontroller for encrypted data acquisition and BLE transmission. \item A cross-platform mobile application providing live CPR feedback, AED navigation, and training statistics. \item A backend infrastructure for user management, performance tracking, and AED location data, built with Node.js and PostgreSQL. \item Integration of haptic, visual, and auditory cues for intuitive user guidance during CPR. \end{itemize} \section{Thesis Outline} The remainder of this thesis is structured as follows: \begin{itemize} \item Chapter 2 reviews existing literature and technologies relevant to CPR, wearables, and emergency systems. \item Chapter 3 presents an overview of the CPR Assist system architecture and its components. \item Chapter 4 focuses on the hardware design and integration of the glove and its sensors. \item Chapter 5 details the firmware, mobile app, and backend implementation. \item Chapter 6 describes the AED navigation and emergency response capabilities. \item Chapter 7 covers the training mode, performance tracking, and gamification features. \item Chapter 8 evaluates the system through functional testing and simulated scenarios. \item Chapter 9 concludes the thesis and discusses future development opportunities. \end{itemize}

**ChatGPT said:**

This is excellent — you've cleanly captured the key points from the structure note and expressed them with clarity and professionalism. Just a few refinements to improve flow and precision:

**✅ Suggested Edits:**

1. **Section 1 - Motivation**: Slight rewording for rhythm.
2. **Section 2 - Problem Statement**: Strengthen the framing of "real-time guidance".
3. **Section 3 - Project Objectives**: Tighten one or two long sentences.
4. **Section 4 - Contributions**: Perfect as-is.
5. **Section 5 - Thesis Outline**: Add consistency in phrasing.

**✍️ Revised Version (minimal, polished)**

\section{Motivation} Cardiac arrest remains one of the leading causes of sudden death worldwide. Survival rates are closely linked to the quality and immediacy of cardiopulmonary resuscitation (CPR) administered by bystanders. Evidence shows that early and effective CPR can double or even triple a person's chances of survival. However, many individuals hesitate to intervene or perform CPR incorrectly—especially under stress. Common issues include inadequate compression depth, incorrect frequency, poor hand placement, and rapid onset of fatigue. These challenges highlight the need for accessible tools that can guide users and enhance CPR performance through real-time feedback. \section{Problem Statement} Despite CPR’s critical role in survival, most bystanders do not have access to systems that support them in real time. Existing CPR feedback devices are often limited to professional training environments due to cost, size, or complexity. There is a clear gap in affordable, wearable technologies that offer intuitive, context-aware feedback and connect with broader emergency support systems. Even trained responders can experience difficulty maintaining proper technique or locating a nearby Automated External Defibrillator (AED) during an emergency. This thesis addresses the absence of portable, connected, and user-friendly CPR assistance systems that can improve both practice and performance in real-world interventions. \section{Project Objectives} This thesis presents the CPR Assist Glove: a smart wearable designed to improve the quality of CPR through immediate feedback and integrated emergency communication. The glove incorporates sensors to monitor compression depth, rate, hand angle, and signs of rescuer fatigue. It transmits encrypted data via Bluetooth Low Energy (BLE) to a cross-platform mobile application developed in Flutter. The app provides real-time visual, auditory, and haptic feedback to guide the user, and includes an emergency mode that notifies nearby responders, transmits the user’s location, and displays directions to the nearest AED. A training mode further enables performance tracking and feedback, with session data stored in a connected backend system. \section{Contributions} The key contributions of this thesis are: \begin{itemize} \item The design and prototyping of a wearable glove system integrating pressure, motion, heart rate, and temperature sensors. \item Development of real-time firmware on the ESP32 microcontroller for encrypted data acquisition and BLE transmission. \item A cross-platform mobile application providing live CPR feedback, AED navigation, and training statistics. \item A backend infrastructure for user management, performance tracking, and AED location data, built with Node.js and PostgreSQL. \item Integration of haptic, visual, and auditory cues for intuitive user guidance during CPR. \end{itemize} \section{Thesis Outline} The remainder of this thesis is organized as follows: \begin{itemize} \item Chapter 2 reviews existing literature and technologies related to CPR, wearable systems, and emergency coordination. \item Chapter 3 outlines the overall architecture of the CPR Assist system and its key modules. \item Chapter 4 presents the hardware design, including sensor integration and power management. \item Chapter 5 describes the software and firmware development for the glove, mobile app, and backend. \item Chapter 6 discusses the AED navigation and emergency response features. \item Chapter 7 explains the training mode, session analytics, and gamified feedback mechanisms. \item Chapter 8 evaluates the system through testing in simulated CPR scenarios. \item Chapter 9 concludes the thesis and outlines directions for future development. \end{itemize}

Would you like me to apply this revision directly to your Overleaf document? Or shall we continue to the next chapter (Background and Related Work)?

**You said:**

yes lets apply it and then move on to the next one

**ChatGPT said:**

✅ The refined version of the Introduction is now applied.

Let’s now move on to **Chapter 2: Background and Related Work**.

Would you like me to:

1. Outline the sections you should include there, or
2. Start writing a full draft for that chapter?

Let me know how you want to proceed.

**You said:**

yes make a deep reasearch on the subject of my thesis. Search for related works, gloves, devices , feedback devices, werables, aed locator apps, general wearable devices in healthcare etc, CPR guidlines for respected sources, limitation of current devices and solutions (no real time feedback, bulky...), gap analysis of the reaseac problem. Search for all of these and always cite your findings and work with high impact factor journals and papers. Be carefull of that. Be very thorought and answer like the literature review part should be written -Cite the authors in APA and give the references section -Focus only on peer-reviewed journals, if you can't access the full paper, reading the abstract will be fine, but prioritze papers you can access on the web. Google Scholar is recommended for this task. -Last 10 years papers or some older but really strong papers

**ChatGPT said:**

To perform a thorough literature review, could you please confirm the following details:

1. Should I prioritize literature that involves:
   * CPR-specific wearable technologies only?
   * Or also include broader wearable healthcare devices (like fatigue detection, HR monitoring) for relevant methods?
2. Is there a specific number of papers you want included (e.g., 10, 20+)?
3. Do you want me to include a short summary/critical analysis for each source, or just use them to write the full literature review text?

Once I have this information, I’ll begin the deep research task and deliver a structured literature review with APA citations.

**You said:**

focus more on: CPR-specific wearable technologies only? but also say a bit about wearablehealthcare devices (dont focus too much but write about them as well) I dont have a specific number for the papers but they have to beehigh impact factor papers so i dont think there would be too many. yes if you can include a short summary for each paper as well. after the literaure review. Is there anything else you need to know?

**ChatGPT said:**

Great — I’ll begin a deep literature review focusing on CPR-specific wearable technologies, while also touching on general wearable healthcare devices. I’ll prioritize peer-reviewed papers from the last 10 years with high impact factors, drawing from Google Scholar and journals like IEEE, Nature, JMIR, and Circulation.

The output will include a structured literature review chapter along with APA-style citations and a short critical summary for each referenced paper.

I’ll let you know once the research is complete and ready for review.

Research completed in 11m · 27 sources · 59 searches

Literature Review of Wearable CPR Feedback and AED Integration Technologies

**Literature Review: Wearable CPR Feedback Devices and Related Technologies**

**Importance of High-Quality CPR and Current Guidelines**

High-quality cardiopulmonary resuscitation (CPR) is critical for improving survival after cardiac arrest. Both the American Heart Association (AHA) and European Resuscitation Council (ERC) emphasize that effective chest compressions – with the correct depth, rate, full recoil, and minimal interruptions – are primary determinants of successful resuscitation. For adult CPR, current guidelines recommend compressions at a rate of 100–120 per minute and a depth of at least 50 mm (5 cm). These standards aim to ensure adequate blood flow during cardiac arrest. In fact, the AHA’s 2020 Guidelines reaffirm that **“it may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance”**, underscoring the recognized value of technology in guiding rescuers to meet quality targets.

Despite widespread training efforts, the quality of bystander CPR often remains suboptimal. Lay rescuers may hesitate to start CPR due to fear or lack of confidence, and even trained providers commonly deliver compressions that are too shallow or too slow without feedback. Fatigue also degrades compression depth over time, further compromising CPR quality. Recognizing these challenges, recent consensus statements have labeled CPR quality as a major public health concern and called for solutions to support rescuers in performing guideline-compliant CPR. The AHA and international bodies thus highlight a clear need for tools that can provide **real-time feedback** and coaching to rescuers, helping to maintain adequate compression depth and rate throughout resuscitation.

**Limitations of Current CPR Feedback Devices**

Over the past two decades, several **CPR feedback devices** have been developed to monitor compression quality and provide immediate audiovisual cues to rescuers. These include **standalone puck-like devices** (placed between the rescuer’s hands and the patient’s chest) and feedback-integrated defibrillator pads used by professionals. Studies have shown that such feedback devices can improve CPR performance in training and simulations[mdpi.com](https://www.mdpi.com/2079-6374/11/2/35#:~:text=combination%20of%20two%20sensors,time%20performance%20optimization%20%5B%20134). However, existing solutions suffer from important limitations that have hindered their widespread use, especially by lay rescuers:

* **Rigid, Bulky Form Factors:** Many commercial standalone devices (e.g., the CPR-Plus, CPREzy, CPRmeter) have inflexible plastic enclosures that the rescuer must press on during compressions. While these devices can measure depth and rate effectively, their hard form factor has caused **discomfort and even injuries** to users. For example, an evaluation of the CPREzy device found that although it improved compression quality, **95% of participants experienced pain in the heel of the hand** and one even sustained a soft-tissue hand injury due to the device’s rigidity. Similarly, 20% of users reported wrist or hand discomfort with the CPR-Plus feedback device, especially after prolonged compressions. There are documented cases of **sustained hand injuries** (pain and bruising) among trainees when using the CPRmeter on manikins as well. These findings highlight that hard feedback modules placed between the hands and chest can impede rescuer comfort and potentially discourage use.
* **Lack of Real-Time Feedback in Basic Scenarios:** Integrated feedback is often built into advanced defibrillator systems used by EMS, but those are **inaccessible to laypersons**. Most bystanders do not have a CPR feedback device on hand during an emergency. Standard CPR training manikins in courses may provide feedback to learners, but in real out-of-hospital cardiac arrests, bystanders rarely receive live guidance. The result is that lay rescuers might unknowingly deliver inadequate compressions. This gap has motivated the development of more accessible, standalone devices and mobile apps to support real-time feedback for anyone attempting CPR.
* **Smartphone Applications – Useful but Awkward:** Given the ubiquity of smartphones, researchers have created apps that use the phone’s accelerometer to measure compression depth and rate. These CPR apps can indeed help rescuers maintain better depth over prolonged CPR. However, practical issues limit their utility. Typically, the phone must be **placed under the hands or on the patient’s chest** to capture compressions, or held in one hand. This **hampers proper technique** and can introduce motion artifacts, reducing accuracy. Park et al. (2014) found that using a smartphone app for feedback led to nearly half (48.5%) of rescuers reporting hand pain due to the awkward hand positioning. In short, while smartphone-based feedback is low-cost and widely available, it is not ergonomically ideal for delivering CPR.
* **Limited Metrics and Wearability:** Early feedback devices primarily focused on compression rate and depth. Some did not explicitly measure **full chest recoil** or provide directive feedback on hand position, which are also crucial for perfusion[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20CPR%2C%20stand,accuracy%20but%20also%20the%20usability)[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). Moreover, traditional devices were **not wearable** – they function as external tools rather than integrating seamlessly with the rescuer. This lack of wearability is a barrier to continuous use or carrying the device routinely. Ideally, a feedback system would be light and unobtrusive enough that a responder could wear it or easily carry it, ensuring it is available when needed.

These limitations of current devices (no real-time support for most lay rescuers, bulky uncomfortable hardware in standalones, and impractical phone implementations) point to a clear **gap in resuscitation technology**. There is a need for feedback solutions that are **portable, easy to use, comfortable, and accurate**, so that even non-professionals can confidently perform high-quality CPR. As noted in one recent review, existing software/hardware solutions (like “smart” backboards or dual accelerometer systems) are a start, but *“continued development of optimal and widely available CPR monitoring is a key component to improved performance”*. This has led researchers to explore **wearable devices** as the next generation of CPR feedback tools.

**Emerging Wearable Solutions for CPR Feedback**

**Smartwatches and Accelerometer-Based Wearables**

One line of innovation has repurposed common wearable gadgets – particularly **smartwatches** – to function as CPR feedback devices. Modern smartwatches contain accelerometers and gyroscopes capable of measuring motion and could, in theory, track the rate and depth of chest compressions. Several studies in the last decade tested this concept:

* **Feasibility Studies:** Song et al. (2016) first demonstrated that a smartwatch can feasibly detect chest compression movements and provide feedback tones. In that pilot study, a smartwatch-based app was used by rescuers on manikins, and the device could measure compression rate within a reasonable accuracy, proving the concept of a wrist-worn CPR assistant.
* **Smartwatch RCT by Lu *et al*., 2019:** A more comprehensive randomized controlled trial was conducted by Lu et al. (2019) with 80 participants to evaluate CPR quality with vs. without a feedback smartwatch. In this study, emergency department professionals performed 2-minute CPR sessions on a manikin either **with a custom CPR feedback app on a smartwatch or with no feedback**. The results were striking – the **smartwatch group’s compressions were significantly closer to guideline targets**. Specifically, the no-feedback control group tended to push **too fast (average 129 min⁻¹)** and too shallow (mean depth ~39 mm), whereas those using the smartwatch stayed within recommended pace (112 min⁻¹) and achieved greater depth (~50.9 mm). The proportion of compressions meeting both target depth and rate was effectively **zero without feedback vs. 39% with the smartwatch**, a dramatic improvement. The authors concluded that without real-time guidance, even trained rescuers often compress at suboptimal depth and an excessive rate, and that **wearable feedback can correct both errors in real time**. This study, published in *Resuscitation*, provided high-quality evidence that a smartwatch-based solution can significantly enhance CPR quality in a simulated setting.
* **Advantages and Drawbacks:** Wearable watches are convenient because many rescuers might already own them, and they eliminate the need to place a hard device between the hands and chest. They also free the rescuer’s palms to perform CPR naturally. However, a challenge noted with wrist-worn devices is that the sensor is **offset from the compression site** (on the wrist or arm rather than directly on the sternum). This can compromise the accuracy of certain measurements, especially chest recoil or depth calibration. Additionally, **checking the smartwatch’s screen during CPR is impractical** – the rescuer’s focus should remain on the patient, and looking at one’s wrist is difficult while performing compressions. Lu et al. addressed this by using loud auditory cues (and presumably vibrations or tones), so that visual checking was not required. Nonetheless, some researchers have pointed out that a smartwatch’s position (far from the point of contact) might reduce the precision of depth feedback and that more ergonomic forms could be beneficial. In summary, smartwatches show promise (more accurate than phone apps in at least one comparative study), but there is room for improvement in how feedback is delivered to the rescuer (e.g., haptic vibration or voice prompts instead of relying on a screen) and in ensuring accurate detection of full recoil.

**Smart CPR Gloves with Integrated Sensors**

To address the limitations of rigid devices and distant wrist sensors, researchers have turned to designing **smart gloves** – wearable gloves embedded with pressure and motion sensors that can directly measure compressions at the point of contact. By literally wearing the feedback device on the hands, the idea is to provide more **intuitive, unobtrusive, and accurate** guidance. Several notable developments in this area have emerged:

* **Early Prototypes:** One of the earliest smart CPR glove concepts was by Dellimore et al. (2013), who developed a glove prototype for neonatal CPR that had an accelerometer on the fingernail to measure compression depth. While innovative, this early glove was **cumbersome and difficult to use** in practice. It demonstrated the potential of a glove form-factor, but also showed that proper design (comfort, fit, and calibration) is crucial.
* **Guridi *et al*., 2024 – Soft Glove Design:** A multidisciplinary team from Aalto University and the University of Turku recently introduced a soft, textile-based CPR glove and reported their findings in *IEEE Access* (Guridi et al., 2024). Their **smart glove prototype** is equipped with multiple pressure sensors across the palm and an inertial measurement unit (IMU) on the back of the hand. The pressure sensors (made of e-textile fabric) directly measure force and distribution of compressions, while the IMU tracks motion and orientation. This glove was deliberately designed to be **flexible, lightweight, and to fit the hand comfortably** – addressing the usability issues of earlier devices[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,on%20the%20intelligent%20fusion%20of)[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=pressure%20sensors%20and%20IMUs,wearable%20devices%20in%20healthcare%20settings). In a preliminary evaluation with nine rescuers on a manikin, the glove could **accurately detect key CPR metrics** including compression depth, rate, complete recoil, and interruptions in real time[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). The authors highlight that the glove is *“easily replicable as an alternative for hard case devices,”* underlining its potential as a low-cost, body-compatible solution[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=,wearable%20devices%20in%20healthcare%20settings). In other words, a soft smart glove can provide the same data as a bulky puck sensor, but in a far more ergonomic way. Their results showed high agreement between the glove’s readings and reference measurements, confirming that **wearable e-textile sensors can monitor CPR quality reliably**[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). This proof-of-concept suggests that future rescuers could simply put on a smart glove which not only guides their technique with audio/visual cues but also avoids the discomfort of holding a separate device.
* **ResuGlove by Kahsay *et al*., 2025:** Building on earlier work, Kahsay et al. developed the **“ResuGlove,”** a soft resuscitation glove with pressure sensors (three on the palm) and an IMU, and tested its effectiveness in a rigorous crossover manikin study. Thirty nursing students performed CPR with and without the glove feedback in randomized order. The glove system provided real-time coaching (in this case via audio prompts from a connected laptop) on compression depth, rate, and recoil. The study’s outcomes, published in 2025, showed that the ResuGlove significantly **improved several quality parameters** of CPR compared to standard practice. Notably, while the average compression depth and rate were similar with or without the glove (both groups achieved around 53 mm depth and ~112 compressions/min on average, as all participants had some training), **the consistency and correctness of compressions were much higher with the glove**. With feedback, a far greater fraction of compressions met the target depth and rate: 82.8% of compressions were within adequate depth range with ResuGlove vs. only 41.4% with standard CPR. Likewise, 96.6% of compressions were in the correct rate range with the glove, compared to 72.4% without it. The glove group also had significantly better **full chest recoil**, with more complete releases between compressions (a critical aspect that novices often neglect). Importantly, users rated the glove’s usability favorably (System Usability Scale score ~70.4, which is in the acceptable range), and no significant discomfort was reported aside from minor tightness. This indicates that a well-designed feedback glove can be both effective and user-friendly. The authors conclude that such **wearable CPR coaches** can enhance layperson performance and possibly confidence, addressing some root causes of poor bystander CPR. The ResuGlove work demonstrates real progress in making feedback devices softer, more flexible, and integrated with the rescuer’s natural movement, thereby overcoming the “rigidity” drawback of earlier tools.
* **Musiari *et al*., 2021 – Coaching Glove for Lay Rescuers:** Another compelling development is the CPR coaching glove tested by Musiari et al. (2021) in Switzerland. Published in *Frontiers in Cardiovascular Medicine*, this study focused on **untrained laypersons** performing CPR with a novel glove device. The glove provided **both visual and voice prompts** to guide compression rate and depth. In a controlled trial with ~130 volunteers, the group using the “glove-coach” was compared to a control group without feedback during 2-minute CPR sessions on an advanced manikin. The findings showed the glove significantly enhanced performance in non-professionals. The **glove group’s average compression rate was 118 per minute vs. 103 per minute in controls** – effectively keeping them in the ideal 100–120 range, whereas those without feedback tended to fall below 100 as they tired. Additionally, participants wearing the glove spent **92.4% of the time compressing at the correct rate**, compared to 71% in the control group. This indicates much more consistent pacing. The **depth of compressions** on average was slightly lower in the glove group (52 mm vs 55 mm), but importantly the glove prevented the typical decay in depth over time due to fatigue. In the control group, compression depth dropped by over 5 mm per minute as the 2-minute CPR went on, whereas with glove feedback the drop was only ~0.8 mm per minute. In short, the feedback glove helped lay rescuers **maintain their compression quality over time**, addressing the issue of unperceived fatigue. The study concluded that the glove’s continuous auditory and visual coaching was effective in guiding inexperienced rescuers to perform CPR closer to guideline recommendations. Such evidence is encouraging, as it directly demonstrates benefits in the target population of laypersons. The device tested by Musiari and colleagues was a prototype (wired to a computer for signal processing), yet it showed that a glove-based system can measurably improve CPR metrics even in those with minimal training. This supports the idea that wearable CPR aids could be deployed for public use to raise the overall standard of bystander CPR.

In summary, **smart CPR gloves** represent a promising advancement that tackles the shortcomings of earlier devices. By integrating sensors into a comfortable glove, they ensure the feedback mechanism is **“built-in” to the rescuer’s hands**, eliminating the need for a separate rigid interface. The latest studies on these gloves – from proof-of-concept accuracy tests[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest) to randomized trials in manikins and with laypersons – consistently show improved CPR quality and good user acceptance. These wearables provide real-time coaching on all key CPR metrics (rate, depth, recoil, and even hand position), and they do so with less discomfort or hindrance than previous solutions. It is worth noting that as of now, these gloves are largely in prototype or early commercial stages; further research and development will be needed to refine their durability, ease of use (wireless or standalone operation), and integration into CPR training programs. Nonetheless, they clearly fill a *gap* by offering **truly wearable, hands-on feedback technology** for resuscitation.

**Other Novel Wearables: Rings and Vest Systems**

Beyond gloves and watches, researchers have explored other form factors like **smart rings** and integrated clothing to assist CPR:

* **Smart-Ring for Compression Depth:** Lim *et al*. (2021) introduced a small ring-shaped device that a rescuer can wear on their finger, termed a **CPR Smart Ring**. This ring contains a miniaturized IMU (accelerometer and gyroscope) and was designed specifically to measure **compression depth** without being affected by wrist movement. The ring’s algorithm accounts for finger orientation and uses a high-pass filter with double-integration of acceleration to compute how far the chest is depressed. In tests on adult and infant manikins, the smart-ring’s depth measurements were highly accurate – within about **±2 mm error of a reference sensor**. Such precision is quite acceptable for CPR purposes, indicating the ring can reliably gauge if compressions reach the 50 mm mark. The benefit of a ring is that it’s extremely lightweight (the prototype was ~6 g) and doesn’t interfere with hand placement since it’s just worn on a finger. The study reported that the ring worked across different CPR methods (one-hand vs. two-thumb techniques, etc.), making it versatile. However, like the smartwatch, a ring alone might need a linked display or audio feedback mechanism to coach the rescuer in real time; the publication by Lim et al. focused on the device’s sensing accuracy rather than a full feedback system. Still, this concept suggests that even **minimalist wearables** like rings could play a role in CPR support, especially if integrated with smartphone apps via Bluetooth to provide prompts.
* **Wearable Patches and Vest Devices:** Some researchers have looked at adhesive sensor patches or vest-like wearables that could be placed on the patient rather than the rescuer. For instance, “smart clothing” with built-in compression sensors has been theorized for patient monitoring. However, most such systems are in early stages or focus on monitoring only. A *smart backboard* that measures force and deflection was one idea to guide CPR, but it’s not practical outside of hospitals. The general trend is moving away from large form factors toward **wearer-centric devices** (like gloves, rings, wristbands) that a responder could carry with them. The glove and ring approaches described above align with that trend, prioritizing portability and ease of deployment.

Collectively, the emergence of **CPR wearables** represents a significant evolution in resuscitation technology. They aim to make real-time feedback **more accessible, comfortable, and tailored to both lay rescuers and professionals**. By leveraging sensors embedded on the rescuer’s body, these devices overcome many pain points of earlier feedback tools. The evidence so far – improved compression depth consistency, better maintenance of rate, reduced fatigue effects, and positive user reception – indicates that wearable feedback devices can effectively close the gap between CPR guidelines and actual performance in the field. As these technologies continue to advance, we may soon see them integrated into standard CPR training (for example, trainees practicing with feedback gloves to build good habits) and even made available in public spaces alongside AEDs for use by Good Samaritans.

**Mobile Apps and AED Locator Technologies in Resuscitation**

Another crucial technological avenue in improving cardiac arrest outcomes involves **mobile applications** – not for compression feedback per se, but for empowering bystanders in other ways, such as early defibrillation and alerting rescuers. Sudden cardiac arrest survival is greatly improved by rapid use of an automated external defibrillator (AED) and early CPR. However, public-access AEDs are often underutilized because people may not know where to find them or even to look for one. To tackle this, developers and public health agencies have created smartphone apps that: (a) **crowdsource AED locations** and guide users to the nearest device, and (b) **dispatch trained volunteers** to nearby cardiac arrest emergencies (to start CPR before EMS arrives).

One example is the development of AED locator apps. **Geolocation-based apps** allow users or emergency dispatchers to quickly identify and navigate to the closest AED. Eiri et al. (2025) describe a project in Brazil that built the “Local DEA” app, which maps AEDs in a city and provides step-by-step directions to the nearest one in an emergency. The app also contains brief CPR instructions and AED usage guidance for the layperson. In simulation tests, this app significantly **reduced the time to defibrillation** by guiding rescuers to strategically placed AEDs faster than an ambulance could typically arrive. The evaluation demonstrated that ensuring AEDs are **well-located and easily found via an app can cut response times by minutes**, which is life-saving given that each minute of delay in defibrillation reduces survival by ~7-10%. Experts who reviewed the Local DEA app rated it highly on usability (Cronbach’s α = 0.92), suggesting that even in high-stress scenarios the interface was user-friendly. The authors conclude that such an AED geolocation app is a *“promising tool for reducing mortality in OHCA”*, especially when paired with broad deployment of AED devices in the community. In essence, technology that quickly connects people to AEDs can bridge the gap between an available defibrillator and its actual use on the patient.

In addition to AED locators, there are now widely used apps (e.g., PulsePoint, GoodSAM, or region-specific apps) that create networks of volunteer responders. When a cardiac arrest is reported to 911/112, these apps can **alert nearby volunteers** (often CPR-trained laypeople or off-duty professionals) and direct them to the scene and/or to retrieve an AED. A systematic review and meta-analysis by Hu et al. (2025) looked at 13 such mobile application systems across various countries. The meta-analysis found that implementing mobile alerts for bystanders led to **significant improvements in outcomes**: bystander CPR rates increased (relative risk ~1.25), bystander AED use increased (RR ~1.23), and ultimately survival to hospital discharge improved by ~34% compared to cases without a mobile responder system. Specifically, apps that notify citizen responders were associated with higher odds of return of spontaneous circulation (ROSC) on hospital arrival and better 30-day survival. These are remarkable figures – for example, an app that activates nearby CPR help can raise the chance of survival from ~10% to ~13-14% in some contexts, which equates to thousands of lives saved when scaled nationally. The review highlighted the **“significant potential of mobile applications in enhancing bystander interventions and improving patient outcomes”**, while noting that maximizing effectiveness requires improving public awareness of AEDs and achieving high volunteer coverage. In summary, mobile technology not only helps in guiding individuals during a CPR event (through feedback devices), but also in **marshalling community resources**: getting the right people and tools (AEDs) to the right place at the right time.

It’s worth noting the synergy between wearable CPR devices and these mobile networks. For instance, a volunteer who is alerted via smartphone to a nearby cardiac arrest could, in the future, also grab a *CPR smart glove* from a public emergency kit or have one as part of a responder pack. They would locate the patient and an AED via the app, and then perform CPR with real-time quality feedback from the wearable device. This combination of technologies – rapid mobilization of responders and optimal performance of CPR – could dramatically improve out-of-hospital cardiac arrest outcomes. Indeed, a comprehensive approach that integrates **AED accessibility, crowd-sourced response, and quality CPR feedback** is emerging as the state-of-the-art in resuscitation science.

**Broader Context: Wearable Technology in Healthcare**

The advancements in CPR-specific wearables are part of a larger wave of **wearable technology in healthcare**. Over the past decade, wearable devices (such as fitness trackers, smartwatches, smart clothing, and medical sensor patches) have gained traction as tools to monitor health metrics and assist in medical interventions. These technologies empower both patients and clinicians with continuous data and timely feedback. For example, wearables are used for tracking heart rhythms (detecting atrial fibrillation), monitoring physical activity and sleep, measuring vital signs like heart rate and oxygen saturation, and even administering therapies (as in insulin pump patches). The appeal of wearables lies in their ability to provide **unobtrusive, round-the-clock monitoring** and to engage individuals in managing their own health.

A scoping review by Kang and Exworthy (2022) in *JMIR mHealth* synthesized a large body of research on wearables in health and noted that **wearables can empower individuals by assisting with diagnosis, behavior change, and self-monitoring**[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from). In other words, wearing a device that gives you feedback or health insights can motivate healthier behavior and alert you to potential issues sooner. This is very much in line with what CPR feedback wearables aim to do during an emergency – assist a rescuer (who is effectively a “first responder” patient caregiver) to perform optimally, thereby improving patient outcomes. The success of wearables in fitness and chronic disease management (e.g., step counters improving activity levels, or wearable ECG monitors detecting arrhythmias) provides a strong precedent for their usefulness in acute care scenarios like CPR.

In the realm of emergency care, beyond CPR, we also see **wearable vital sign monitors** for first responders (to track their stress or fatigue), augmented reality glasses providing guidance in trauma care, and other innovations. All these share the common goal of leveraging technology to augment human capabilities in healthcare. The trend in wearables is toward making them more comfortable, more integrated (e.g., textiles with sensors that feel like normal clothing), and more intelligent via AI algorithms that can interpret data in real time. For instance, a wearable might not only measure compressions but also use machine learning to advise when to switch rescuers due to fatigue, or to predict outcomes based on CPR quality. While those advanced features are still on the horizon, the current literature firmly supports that **wearable devices are transforming healthcare** by providing continuous support and feedback – whether in daily health maintenance or in life-and-death emergencies[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from).

**Gap Analysis and Future Directions**

Drawing together the insights from the literature, it’s evident that **significant progress** has been made in CPR feedback technology, yet some gaps and challenges remain:

* **From Prototype to Practice:** Many of the wearable CPR devices discussed (smart gloves, rings, etc.) are in prototype or experimental stages. Further development is needed to make them robust, easy to deploy, and affordable. Issues like battery life, wireless connectivity, and one-size-fits-all designs will need to be addressed before these devices can be widely adopted. Future research should focus on human factors engineering of these wearables – for example, ensuring a CPR glove can quickly fit various hand sizes in an emergency, or that a device activates and pairs seamlessly without technical delays.
* **Integration with Emergency Response Systems:** As mobile responder apps and AED mapping become common, integrating CPR feedback wearables into these systems is a next step. This might involve training volunteer responders to use a feedback device or even storing simple devices (like a CPR feedback puck or glove) in public AED cabinets. A fully integrated approach could see dispatchers instructing a 911 caller to use an available device or a nearby volunteer arriving with wearable CPR gear. Establishing protocols for such integration and proving their efficacy in real-world cardiac arrests is a key area for future study.
* **Real-world Efficacy:** Most studies so far have been on manikins or in simulated settings. It remains to be proven how much wearable feedback devices improve outcomes (like ROSC or survival) in actual out-of-hospital cardiac arrests. It is intuitive that better CPR should yield better outcomes, and some in-hospital studies with feedback devices showed improved survival to discharge. However, randomized trials in the field will be needed to quantify the benefit of, say, giving a CPR glove to lay rescuers. Ethical and logistical challenges exist for such trials, but some large EMS systems might pilot the use of wearables in responder programs to gather data on neurological outcomes and survival.
* **Awareness and Training Gaps:** Another aspect is that even the best device is ineffective if people are unaware or unwilling to use it. Public education campaigns will be necessary to promote the use of CPR aids. This includes incorporating feedback devices into standard CPR training courses – in 2015 the AHA actually began **requiring use of an instrumented feedback manikin in certified BLS courses** to improve training quality. Extending that to encourage use of personal or community-owned feedback devices could be the next frontier. The technology must be paired with training and endorsement by authoritative bodies to gain trust.
* **Continued Innovation:** There are still some CPR quality parameters that are hard to measure with wearables – for example, effective ventilation during CPR (for those not doing Hands-Only CPR) or the quality of airway management. Future wearables might integrate additional sensors (for instance, a headset to measure ventilation timing, or an adhesive sensor on the patient to gauge recoil more directly). Additionally, haptic feedback (vibrations on the rescuer’s hands or fingers) is an emerging modality that could supplement audio/visual cues in noisy environments. Researchers are also exploring AI-driven feedback, which could adapt prompts in real time to the situation (e.g., encouraging a faster pace if it detects slowing down, or warning when fatigue likely sets in).

In conclusion, the literature from the last decade paints an optimistic picture: **wearable CPR feedback devices and mobile health technologies can significantly enhance the chain of survival** for cardiac arrest victims. High-impact studies have demonstrated improved CPR performance metrics with feedback gloves, smartwatches, and other devices, while community trials show mobile apps getting more people to perform CPR and use AEDs, ultimately saving lives. The gap between recommended CPR quality and what is actually delivered by lay rescuers is increasingly being narrowed by these technological aids. As Musiari et al. (2021) showed, even individuals with no healthcare background can perform near-professional-quality CPR when guided by a smart device on their hand. This is a profound finding – it suggests that with the right support tools, the general public’s capacity to act in cardiac emergencies can be dramatically improved.

Still, challenges of device adoption, cost, and integration remain. But given the fast pace of innovation and the strong push from organizations like the AHA (which explicitly calls for improved CPR monitoring and feedback solutions), it is likely that the coming years will see these wearable technologies move from the lab and limited trials into mainstream use. The ultimate goal driving all this research is to improve survival and neurological outcomes from cardiac arrest. By empowering rescuers with real-time feedback and connecting them swiftly to AEDs and help, the chances of survival can be significantly increased. The literature review clearly identifies that **the technology is maturing**; the next steps will involve large-scale implementation and rigorous outcome evaluations to truly validate the life-saving impact of wearable CPR feedback devices in real-world scenarios.

**Summary of Key Studies and Sources**

* **Kang & Exworthy (2022)** – *JMIR mHealth and uHealth*: Scoping review of wearable health technology. Concluded that wearables empower users in health management by aiding diagnosis, self-monitoring, and behavior change[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from). Highlights the broad potential of wearables in healthcare beyond just clinical settings.
* **Eiri et al. (2025)** – *PLOS ONE*: Developed the “Local DEA” AED locator app in Brazil. The app provides geolocation of AEDs, navigation, and CPR instructions. Expert evaluation showed high usability, and simulations indicated the app can significantly reduce time to defibrillation when AEDs are well-positioned, thereby potentially improving survival in out-of-hospital cardiac arrest.
* **Hu et al. (2025)** – *BMC Health Services Research*: Systematic review and meta-analysis of mobile responder apps for cardiac arrest (13 studies). Found that mobile alert systems increased bystander CPR and AED use rates and improved survival to hospital discharge by ~34% compared to EMS alone. Validates the effectiveness of smartphone activation of lay rescuers in improving outcomes.
* **Musiari et al. (2021)** – *Frontiers in Cardiovascular Medicine*: Tested a CPR coaching glove with visual/vocal feedback on 130 laypeople. In a controlled trial, the glove significantly improved compression rate maintenance (keeping ~118/min vs 103/min without) and reduced depth decay (nearly eliminating fatigue-related decline). Concludes that a wearable glove coach is effective in guiding untrained rescuers to perform better CPR.
* **Kahsay et al. (2025)** – *Journal of Cardiovascular Nursing*: Evaluated the **ResuGlove** (soft sensor-embedded glove) in a randomized crossover manikin study with 29 trained students. While average depth/rate were similar, the glove feedback led to a much higher proportion of compressions in the correct depth (83% vs 41%) and rate (97% vs 72%) ranges. The glove also improved complete recoil and had acceptable usability. Demonstrates the benefit of a flexible wearable on CPR quality and user comfort.
* **Guridi et al. (2024)** – *IEEE Access*: Presented a proof-of-concept smart CPR glove with e-textile pressure sensors and IMUs. The glove accurately measured depth, rate, recoil, and pauses in real time[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). Authors noted the glove is lightweight and adaptable, offering an alternative to hard devices[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=,wearable%20devices%20in%20healthcare%20settings). This study confirmed the technical feasibility and accuracy of a textile-based wearable for CPR feedback.
* **Lim et al. (2021)** – *Biosensors*: Developed a **smart-ring** CPR feedback device using an IMU. The ring’s depth measurements had very low error (~1–2 mm) in tests, showing it can reliably gauge compression depth. Compared to smartphone and smartwatch placements, the ring (worn on the finger) can be more directly aligned with the compression axis. Proposed as an ultra-compact solution for depth feedback in both adult and infant CPR.
* **Lu et al. (2019)** – *Resuscitation*: RCT on a smartwatch CPR feedback app with 80 healthcare professionals. Found that without feedback, compressions were too fast and shallow (avg 129/min, 39 mm), but with the smartwatch feedback, quality improved to ~112/min and 51 mm depth. The percentage of high-quality compressions was significantly higher in the feedback group. Concludes that real-time feedback via a wearable device markedly improves CPR delivered by rescuers.
* **Song et al. (2016)** – *Resuscitation*: Feasibility study of using smartwatches as compression feedback tools. Demonstrated that a smartwatch accelerometer could detect compressions and provide guidance tones. Though a small study, it opened the door to considering consumer wearables for CPR. Noted that while feasible, attention to the user interface (minimizing need to check the watch) is important.
* **Park et al. (2014)** – *Technology and Health Care*: Investigated a smartphone app for CPR feedback versus standard CPR. While the app improved compression depth maintenance, many users reported discomfort and hand pain when using the phone as a feedback device. This study is frequently cited to illustrate the ergonomic problems with phone-based CPR aids and the need for more user-friendly designs (like wearables).
* **Perkins et al. (2005)** – *Resuscitation*: Evaluated the CPREzy feedback device on a manikin. It improved compression depth significantly, but **95% of users experienced heel-of-hand pain** from the rigid device. One user had a minor injury. Highlights the trade-off observed in early feedback devices: better CPR quality at the cost of rescuer comfort.
* **Elding et al. (1998)** – *Resuscitation*: Studied the CPR-Plus device. Showed improved technique, but about 20% of participants felt wrist/hand discomfort with the device during extended use. As one of the first feedback tool studies, it provided proof that feedback helps but also pointed out user fatigue issues.
* **Hong et al. (2016)** – *Resuscitation (Letter)*: Reported on injuries caused by feedback device use (CPRmeter) during CPR training. Noted nearly 39% of trainees had hand bruises or pain after using the CPRmeter. This letter to the editor underscored that even well-established devices can have side effects, reinforcing the need for **softer, more ergonomic solutions**.

Each of these studies contributed to understanding the landscape of CPR aids – from early rigid devices to modern wearables and mobile apps. Together, they show a clear trajectory toward devices that are **integrated into what rescuers wear or carry**, providing necessary guidance with minimal downsides. The references listed above (all peer-reviewed journal publications) form a solid evidence base for the benefits of feedback technology in resuscitation, as well as the considerations for future improvements in this field.

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**Literature Review: Wearable CPR Feedback Devices and Related Technologies**

**Importance of High-Quality CPR and Current Guidelines**

High-quality cardiopulmonary resuscitation (CPR) is critical for improving survival after cardiac arrest. Both the American Heart Association (AHA) and European Resuscitation Council (ERC) emphasize that effective chest compressions – with the correct depth, rate, full recoil, and minimal interruptions – are primary determinants of successful resuscitation. For adult CPR, current guidelines recommend compressions at a rate of 100–120 per minute and a depth of at least 50 mm (5 cm). These standards aim to ensure adequate blood flow during cardiac arrest. In fact, the AHA’s 2020 Guidelines reaffirm that **“it may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance”**, underscoring the recognized value of technology in guiding rescuers to meet quality targets.

Despite widespread training efforts, the quality of bystander CPR often remains suboptimal. Lay rescuers may hesitate to start CPR due to fear or lack of confidence, and even trained providers commonly deliver compressions that are too shallow or too slow without feedback. Fatigue also degrades compression depth over time, further compromising CPR quality. Recognizing these challenges, recent consensus statements have labeled CPR quality as a major public health concern and called for solutions to support rescuers in performing guideline-compliant CPR. The AHA and international bodies thus highlight a clear need for tools that can provide **real-time feedback** and coaching to rescuers, helping to maintain adequate compression depth and rate throughout resuscitation.

**Limitations of Current CPR Feedback Devices**

Over the past two decades, several **CPR feedback devices** have been developed to monitor compression quality and provide immediate audiovisual cues to rescuers. These include **standalone puck-like devices** (placed between the rescuer’s hands and the patient’s chest) and feedback-integrated defibrillator pads used by professionals. Studies have shown that such feedback devices can improve CPR performance in training and simulations[mdpi.com](https://www.mdpi.com/2079-6374/11/2/35#:~:text=combination%20of%20two%20sensors,time%20performance%20optimization%20%5B%20134). However, existing solutions suffer from important limitations that have hindered their widespread use, especially by lay rescuers:

* **Rigid, Bulky Form Factors:** Many commercial standalone devices (e.g., the CPR-Plus, CPREzy, CPRmeter) have inflexible plastic enclosures that the rescuer must press on during compressions. While these devices can measure depth and rate effectively, their hard form factor has caused **discomfort and even injuries** to users. For example, an evaluation of the CPREzy device found that although it improved compression quality, **95% of participants experienced pain in the heel of the hand** and one even sustained a soft-tissue hand injury due to the device’s rigidity. Similarly, 20% of users reported wrist or hand discomfort with the CPR-Plus feedback device, especially after prolonged compressions. There are documented cases of **sustained hand injuries** (pain and bruising) among trainees when using the CPRmeter on manikins as well. These findings highlight that hard feedback modules placed between the hands and chest can impede rescuer comfort and potentially discourage use.
* **Lack of Real-Time Feedback in Basic Scenarios:** Integrated feedback is often built into advanced defibrillator systems used by EMS, but those are **inaccessible to laypersons**. Most bystanders do not have a CPR feedback device on hand during an emergency. Standard CPR training manikins in courses may provide feedback to learners, but in real out-of-hospital cardiac arrests, bystanders rarely receive live guidance. The result is that lay rescuers might unknowingly deliver inadequate compressions. This gap has motivated the development of more accessible, standalone devices and mobile apps to support real-time feedback for anyone attempting CPR.
* **Smartphone Applications – Useful but Awkward:** Given the ubiquity of smartphones, researchers have created apps that use the phone’s accelerometer to measure compression depth and rate. These CPR apps can indeed help rescuers maintain better depth over prolonged CPR. However, practical issues limit their utility. Typically, the phone must be **placed under the hands or on the patient’s chest** to capture compressions, or held in one hand. This **hampers proper technique** and can introduce motion artifacts, reducing accuracy. Park et al. (2014) found that using a smartphone app for feedback led to nearly half (48.5%) of rescuers reporting hand pain due to the awkward hand positioning. In short, while smartphone-based feedback is low-cost and widely available, it is not ergonomically ideal for delivering CPR.
* **Limited Metrics and Wearability:** Early feedback devices primarily focused on compression rate and depth. Some did not explicitly measure **full chest recoil** or provide directive feedback on hand position, which are also crucial for perfusion[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20CPR%2C%20stand,accuracy%20but%20also%20the%20usability)[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). Moreover, traditional devices were **not wearable** – they function as external tools rather than integrating seamlessly with the rescuer. This lack of wearability is a barrier to continuous use or carrying the device routinely. Ideally, a feedback system would be light and unobtrusive enough that a responder could wear it or easily carry it, ensuring it is available when needed.

These limitations of current devices (no real-time support for most lay rescuers, bulky uncomfortable hardware in standalones, and impractical phone implementations) point to a clear **gap in resuscitation technology**. There is a need for feedback solutions that are **portable, easy to use, comfortable, and accurate**, so that even non-professionals can confidently perform high-quality CPR. As noted in one recent review, existing software/hardware solutions (like “smart” backboards or dual accelerometer systems) are a start, but *“continued development of optimal and widely available CPR monitoring is a key component to improved performance”*. This has led researchers to explore **wearable devices** as the next generation of CPR feedback tools.

**Emerging Wearable Solutions for CPR Feedback**

**Smartwatches and Accelerometer-Based Wearables**

One line of innovation has repurposed common wearable gadgets – particularly **smartwatches** – to function as CPR feedback devices. Modern smartwatches contain accelerometers and gyroscopes capable of measuring motion and could, in theory, track the rate and depth of chest compressions. Several studies in the last decade tested this concept:

* **Feasibility Studies:** Song et al. (2016) first demonstrated that a smartwatch can feasibly detect chest compression movements and provide feedback tones. In that pilot study, a smartwatch-based app was used by rescuers on manikins, and the device could measure compression rate within a reasonable accuracy, proving the concept of a wrist-worn CPR assistant.
* **Smartwatch RCT by Lu *et al*., 2019:** A more comprehensive randomized controlled trial was conducted by Lu et al. (2019) with 80 participants to evaluate CPR quality with vs. without a feedback smartwatch. In this study, emergency department professionals performed 2-minute CPR sessions on a manikin either **with a custom CPR feedback app on a smartwatch or with no feedback**. The results were striking – the **smartwatch group’s compressions were significantly closer to guideline targets**. Specifically, the no-feedback control group tended to push **too fast (average 129 min⁻¹)** and too shallow (mean depth ~39 mm), whereas those using the smartwatch stayed within recommended pace (112 min⁻¹) and achieved greater depth (~50.9 mm). The proportion of compressions meeting both target depth and rate was effectively **zero without feedback vs. 39% with the smartwatch**, a dramatic improvement. The authors concluded that without real-time guidance, even trained rescuers often compress at suboptimal depth and an excessive rate, and that **wearable feedback can correct both errors in real time**. This study, published in *Resuscitation*, provided high-quality evidence that a smartwatch-based solution can significantly enhance CPR quality in a simulated setting.
* **Advantages and Drawbacks:** Wearable watches are convenient because many rescuers might already own them, and they eliminate the need to place a hard device between the hands and chest. They also free the rescuer’s palms to perform CPR naturally. However, a challenge noted with wrist-worn devices is that the sensor is **offset from the compression site** (on the wrist or arm rather than directly on the sternum). This can compromise the accuracy of certain measurements, especially chest recoil or depth calibration. Additionally, **checking the smartwatch’s screen during CPR is impractical** – the rescuer’s focus should remain on the patient, and looking at one’s wrist is difficult while performing compressions. Lu et al. addressed this by using loud auditory cues (and presumably vibrations or tones), so that visual checking was not required. Nonetheless, some researchers have pointed out that a smartwatch’s position (far from the point of contact) might reduce the precision of depth feedback and that more ergonomic forms could be beneficial. In summary, smartwatches show promise (more accurate than phone apps in at least one comparative study), but there is room for improvement in how feedback is delivered to the rescuer (e.g., haptic vibration or voice prompts instead of relying on a screen) and in ensuring accurate detection of full recoil.

**Smart CPR Gloves with Integrated Sensors**

To address the limitations of rigid devices and distant wrist sensors, researchers have turned to designing **smart gloves** – wearable gloves embedded with pressure and motion sensors that can directly measure compressions at the point of contact. By literally wearing the feedback device on the hands, the idea is to provide more **intuitive, unobtrusive, and accurate** guidance. Several notable developments in this area have emerged:

* **Early Prototypes:** One of the earliest smart CPR glove concepts was by Dellimore et al. (2013), who developed a glove prototype for neonatal CPR that had an accelerometer on the fingernail to measure compression depth. While innovative, this early glove was **cumbersome and difficult to use** in practice. It demonstrated the potential of a glove form-factor, but also showed that proper design (comfort, fit, and calibration) is crucial.
* **Guridi *et al*., 2024 – Soft Glove Design:** A multidisciplinary team from Aalto University and the University of Turku recently introduced a soft, textile-based CPR glove and reported their findings in *IEEE Access* (Guridi et al., 2024). Their **smart glove prototype** is equipped with multiple pressure sensors across the palm and an inertial measurement unit (IMU) on the back of the hand. The pressure sensors (made of e-textile fabric) directly measure force and distribution of compressions, while the IMU tracks motion and orientation. This glove was deliberately designed to be **flexible, lightweight, and to fit the hand comfortably** – addressing the usability issues of earlier devices[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,on%20the%20intelligent%20fusion%20of)[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=pressure%20sensors%20and%20IMUs,wearable%20devices%20in%20healthcare%20settings). In a preliminary evaluation with nine rescuers on a manikin, the glove could **accurately detect key CPR metrics** including compression depth, rate, complete recoil, and interruptions in real time[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). The authors highlight that the glove is *“easily replicable as an alternative for hard case devices,”* underlining its potential as a low-cost, body-compatible solution[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=,wearable%20devices%20in%20healthcare%20settings). In other words, a soft smart glove can provide the same data as a bulky puck sensor, but in a far more ergonomic way. Their results showed high agreement between the glove’s readings and reference measurements, confirming that **wearable e-textile sensors can monitor CPR quality reliably**[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). This proof-of-concept suggests that future rescuers could simply put on a smart glove which not only guides their technique with audio/visual cues but also avoids the discomfort of holding a separate device.
* **ResuGlove by Kahsay *et al*., 2025:** Building on earlier work, Kahsay et al. developed the **“ResuGlove,”** a soft resuscitation glove with pressure sensors (three on the palm) and an IMU, and tested its effectiveness in a rigorous crossover manikin study. Thirty nursing students performed CPR with and without the glove feedback in randomized order. The glove system provided real-time coaching (in this case via audio prompts from a connected laptop) on compression depth, rate, and recoil. The study’s outcomes, published in 2025, showed that the ResuGlove significantly **improved several quality parameters** of CPR compared to standard practice. Notably, while the average compression depth and rate were similar with or without the glove (both groups achieved around 53 mm depth and ~112 compressions/min on average, as all participants had some training), **the consistency and correctness of compressions were much higher with the glove**. With feedback, a far greater fraction of compressions met the target depth and rate: 82.8% of compressions were within adequate depth range with ResuGlove vs. only 41.4% with standard CPR. Likewise, 96.6% of compressions were in the correct rate range with the glove, compared to 72.4% without it. The glove group also had significantly better **full chest recoil**, with more complete releases between compressions (a critical aspect that novices often neglect). Importantly, users rated the glove’s usability favorably (System Usability Scale score ~70.4, which is in the acceptable range), and no significant discomfort was reported aside from minor tightness. This indicates that a well-designed feedback glove can be both effective and user-friendly. The authors conclude that such **wearable CPR coaches** can enhance layperson performance and possibly confidence, addressing some root causes of poor bystander CPR. The ResuGlove work demonstrates real progress in making feedback devices softer, more flexible, and integrated with the rescuer’s natural movement, thereby overcoming the “rigidity” drawback of earlier tools.
* **Musiari *et al*., 2021 – Coaching Glove for Lay Rescuers:** Another compelling development is the CPR coaching glove tested by Musiari et al. (2021) in Switzerland. Published in *Frontiers in Cardiovascular Medicine*, this study focused on **untrained laypersons** performing CPR with a novel glove device. The glove provided **both visual and voice prompts** to guide compression rate and depth. In a controlled trial with ~130 volunteers, the group using the “glove-coach” was compared to a control group without feedback during 2-minute CPR sessions on an advanced manikin. The findings showed the glove significantly enhanced performance in non-professionals. The **glove group’s average compression rate was 118 per minute vs. 103 per minute in controls** – effectively keeping them in the ideal 100–120 range, whereas those without feedback tended to fall below 100 as they tired. Additionally, participants wearing the glove spent **92.4% of the time compressing at the correct rate**, compared to 71% in the control group. This indicates much more consistent pacing. The **depth of compressions** on average was slightly lower in the glove group (52 mm vs 55 mm), but importantly the glove prevented the typical decay in depth over time due to fatigue. In the control group, compression depth dropped by over 5 mm per minute as the 2-minute CPR went on, whereas with glove feedback the drop was only ~0.8 mm per minute. In short, the feedback glove helped lay rescuers **maintain their compression quality over time**, addressing the issue of unperceived fatigue. The study concluded that the glove’s continuous auditory and visual coaching was effective in guiding inexperienced rescuers to perform CPR closer to guideline recommendations. Such evidence is encouraging, as it directly demonstrates benefits in the target population of laypersons. The device tested by Musiari and colleagues was a prototype (wired to a computer for signal processing), yet it showed that a glove-based system can measurably improve CPR metrics even in those with minimal training. This supports the idea that wearable CPR aids could be deployed for public use to raise the overall standard of bystander CPR.

In summary, **smart CPR gloves** represent a promising advancement that tackles the shortcomings of earlier devices. By integrating sensors into a comfortable glove, they ensure the feedback mechanism is **“built-in” to the rescuer’s hands**, eliminating the need for a separate rigid interface. The latest studies on these gloves – from proof-of-concept accuracy tests[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest) to randomized trials in manikins and with laypersons – consistently show improved CPR quality and good user acceptance. These wearables provide real-time coaching on all key CPR metrics (rate, depth, recoil, and even hand position), and they do so with less discomfort or hindrance than previous solutions. It is worth noting that as of now, these gloves are largely in prototype or early commercial stages; further research and development will be needed to refine their durability, ease of use (wireless or standalone operation), and integration into CPR training programs. Nonetheless, they clearly fill a *gap* by offering **truly wearable, hands-on feedback technology** for resuscitation.

**Other Novel Wearables: Rings and Vest Systems**

Beyond gloves and watches, researchers have explored other form factors like **smart rings** and integrated clothing to assist CPR:

* **Smart-Ring for Compression Depth:** Lim *et al*. (2021) introduced a small ring-shaped device that a rescuer can wear on their finger, termed a **CPR Smart Ring**. This ring contains a miniaturized IMU (accelerometer and gyroscope) and was designed specifically to measure **compression depth** without being affected by wrist movement. The ring’s algorithm accounts for finger orientation and uses a high-pass filter with double-integration of acceleration to compute how far the chest is depressed. In tests on adult and infant manikins, the smart-ring’s depth measurements were highly accurate – within about **±2 mm error of a reference sensor**. Such precision is quite acceptable for CPR purposes, indicating the ring can reliably gauge if compressions reach the 50 mm mark. The benefit of a ring is that it’s extremely lightweight (the prototype was ~6 g) and doesn’t interfere with hand placement since it’s just worn on a finger. The study reported that the ring worked across different CPR methods (one-hand vs. two-thumb techniques, etc.), making it versatile. However, like the smartwatch, a ring alone might need a linked display or audio feedback mechanism to coach the rescuer in real time; the publication by Lim et al. focused on the device’s sensing accuracy rather than a full feedback system. Still, this concept suggests that even **minimalist wearables** like rings could play a role in CPR support, especially if integrated with smartphone apps via Bluetooth to provide prompts.
* **Wearable Patches and Vest Devices:** Some researchers have looked at adhesive sensor patches or vest-like wearables that could be placed on the patient rather than the rescuer. For instance, “smart clothing” with built-in compression sensors has been theorized for patient monitoring. However, most such systems are in early stages or focus on monitoring only. A *smart backboard* that measures force and deflection was one idea to guide CPR, but it’s not practical outside of hospitals. The general trend is moving away from large form factors toward **wearer-centric devices** (like gloves, rings, wristbands) that a responder could carry with them. The glove and ring approaches described above align with that trend, prioritizing portability and ease of deployment.

Collectively, the emergence of **CPR wearables** represents a significant evolution in resuscitation technology. They aim to make real-time feedback **more accessible, comfortable, and tailored to both lay rescuers and professionals**. By leveraging sensors embedded on the rescuer’s body, these devices overcome many pain points of earlier feedback tools. The evidence so far – improved compression depth consistency, better maintenance of rate, reduced fatigue effects, and positive user reception – indicates that wearable feedback devices can effectively close the gap between CPR guidelines and actual performance in the field. As these technologies continue to advance, we may soon see them integrated into standard CPR training (for example, trainees practicing with feedback gloves to build good habits) and even made available in public spaces alongside AEDs for use by Good Samaritans.

**Mobile Apps and AED Locator Technologies in Resuscitation**

Another crucial technological avenue in improving cardiac arrest outcomes involves **mobile applications** – not for compression feedback per se, but for empowering bystanders in other ways, such as early defibrillation and alerting rescuers. Sudden cardiac arrest survival is greatly improved by rapid use of an automated external defibrillator (AED) and early CPR. However, public-access AEDs are often underutilized because people may not know where to find them or even to look for one. To tackle this, developers and public health agencies have created smartphone apps that: (a) **crowdsource AED locations** and guide users to the nearest device, and (b) **dispatch trained volunteers** to nearby cardiac arrest emergencies (to start CPR before EMS arrives).

One example is the development of AED locator apps. **Geolocation-based apps** allow users or emergency dispatchers to quickly identify and navigate to the closest AED. Eiri et al. (2025) describe a project in Brazil that built the “Local DEA” app, which maps AEDs in a city and provides step-by-step directions to the nearest one in an emergency. The app also contains brief CPR instructions and AED usage guidance for the layperson. In simulation tests, this app significantly **reduced the time to defibrillation** by guiding rescuers to strategically placed AEDs faster than an ambulance could typically arrive. The evaluation demonstrated that ensuring AEDs are **well-located and easily found via an app can cut response times by minutes**, which is life-saving given that each minute of delay in defibrillation reduces survival by ~7-10%. Experts who reviewed the Local DEA app rated it highly on usability (Cronbach’s α = 0.92), suggesting that even in high-stress scenarios the interface was user-friendly. The authors conclude that such an AED geolocation app is a *“promising tool for reducing mortality in OHCA”*, especially when paired with broad deployment of AED devices in the community. In essence, technology that quickly connects people to AEDs can bridge the gap between an available defibrillator and its actual use on the patient.

In addition to AED locators, there are now widely used apps (e.g., PulsePoint, GoodSAM, or region-specific apps) that create networks of volunteer responders. When a cardiac arrest is reported to 911/112, these apps can **alert nearby volunteers** (often CPR-trained laypeople or off-duty professionals) and direct them to the scene and/or to retrieve an AED. A systematic review and meta-analysis by Hu et al. (2025) looked at 13 such mobile application systems across various countries. The meta-analysis found that implementing mobile alerts for bystanders led to **significant improvements in outcomes**: bystander CPR rates increased (relative risk ~1.25), bystander AED use increased (RR ~1.23), and ultimately survival to hospital discharge improved by ~34% compared to cases without a mobile responder system. Specifically, apps that notify citizen responders were associated with higher odds of return of spontaneous circulation (ROSC) on hospital arrival and better 30-day survival. These are remarkable figures – for example, an app that activates nearby CPR help can raise the chance of survival from ~10% to ~13-14% in some contexts, which equates to thousands of lives saved when scaled nationally. The review highlighted the **“significant potential of mobile applications in enhancing bystander interventions and improving patient outcomes”**, while noting that maximizing effectiveness requires improving public awareness of AEDs and achieving high volunteer coverage. In summary, mobile technology not only helps in guiding individuals during a CPR event (through feedback devices), but also in **marshalling community resources**: getting the right people and tools (AEDs) to the right place at the right time.

It’s worth noting the synergy between wearable CPR devices and these mobile networks. For instance, a volunteer who is alerted via smartphone to a nearby cardiac arrest could, in the future, also grab a *CPR smart glove* from a public emergency kit or have one as part of a responder pack. They would locate the patient and an AED via the app, and then perform CPR with real-time quality feedback from the wearable device. This combination of technologies – rapid mobilization of responders and optimal performance of CPR – could dramatically improve out-of-hospital cardiac arrest outcomes. Indeed, a comprehensive approach that integrates **AED accessibility, crowd-sourced response, and quality CPR feedback** is emerging as the state-of-the-art in resuscitation science.

**Broader Context: Wearable Technology in Healthcare**

The advancements in CPR-specific wearables are part of a larger wave of **wearable technology in healthcare**. Over the past decade, wearable devices (such as fitness trackers, smartwatches, smart clothing, and medical sensor patches) have gained traction as tools to monitor health metrics and assist in medical interventions. These technologies empower both patients and clinicians with continuous data and timely feedback. For example, wearables are used for tracking heart rhythms (detecting atrial fibrillation), monitoring physical activity and sleep, measuring vital signs like heart rate and oxygen saturation, and even administering therapies (as in insulin pump patches). The appeal of wearables lies in their ability to provide **unobtrusive, round-the-clock monitoring** and to engage individuals in managing their own health.

A scoping review by Kang and Exworthy (2022) in *JMIR mHealth* synthesized a large body of research on wearables in health and noted that **wearables can empower individuals by assisting with diagnosis, behavior change, and self-monitoring**[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from). In other words, wearing a device that gives you feedback or health insights can motivate healthier behavior and alert you to potential issues sooner. This is very much in line with what CPR feedback wearables aim to do during an emergency – assist a rescuer (who is effectively a “first responder” patient caregiver) to perform optimally, thereby improving patient outcomes. The success of wearables in fitness and chronic disease management (e.g., step counters improving activity levels, or wearable ECG monitors detecting arrhythmias) provides a strong precedent for their usefulness in acute care scenarios like CPR.

In the realm of emergency care, beyond CPR, we also see **wearable vital sign monitors** for first responders (to track their stress or fatigue), augmented reality glasses providing guidance in trauma care, and other innovations. All these share the common goal of leveraging technology to augment human capabilities in healthcare. The trend in wearables is toward making them more comfortable, more integrated (e.g., textiles with sensors that feel like normal clothing), and more intelligent via AI algorithms that can interpret data in real time. For instance, a wearable might not only measure compressions but also use machine learning to advise when to switch rescuers due to fatigue, or to predict outcomes based on CPR quality. While those advanced features are still on the horizon, the current literature firmly supports that **wearable devices are transforming healthcare** by providing continuous support and feedback – whether in daily health maintenance or in life-and-death emergencies[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from).

**Gap Analysis and Future Directions**

Drawing together the insights from the literature, it’s evident that **significant progress** has been made in CPR feedback technology, yet some gaps and challenges remain:

* **From Prototype to Practice:** Many of the wearable CPR devices discussed (smart gloves, rings, etc.) are in prototype or experimental stages. Further development is needed to make them robust, easy to deploy, and affordable. Issues like battery life, wireless connectivity, and one-size-fits-all designs will need to be addressed before these devices can be widely adopted. Future research should focus on human factors engineering of these wearables – for example, ensuring a CPR glove can quickly fit various hand sizes in an emergency, or that a device activates and pairs seamlessly without technical delays.
* **Integration with Emergency Response Systems:** As mobile responder apps and AED mapping become common, integrating CPR feedback wearables into these systems is a next step. This might involve training volunteer responders to use a feedback device or even storing simple devices (like a CPR feedback puck or glove) in public AED cabinets. A fully integrated approach could see dispatchers instructing a 911 caller to use an available device or a nearby volunteer arriving with wearable CPR gear. Establishing protocols for such integration and proving their efficacy in real-world cardiac arrests is a key area for future study.
* **Real-world Efficacy:** Most studies so far have been on manikins or in simulated settings. It remains to be proven how much wearable feedback devices improve outcomes (like ROSC or survival) in actual out-of-hospital cardiac arrests. It is intuitive that better CPR should yield better outcomes, and some in-hospital studies with feedback devices showed improved survival to discharge. However, randomized trials in the field will be needed to quantify the benefit of, say, giving a CPR glove to lay rescuers. Ethical and logistical challenges exist for such trials, but some large EMS systems might pilot the use of wearables in responder programs to gather data on neurological outcomes and survival.
* **Awareness and Training Gaps:** Another aspect is that even the best device is ineffective if people are unaware or unwilling to use it. Public education campaigns will be necessary to promote the use of CPR aids. This includes incorporating feedback devices into standard CPR training courses – in 2015 the AHA actually began **requiring use of an instrumented feedback manikin in certified BLS courses** to improve training quality. Extending that to encourage use of personal or community-owned feedback devices could be the next frontier. The technology must be paired with training and endorsement by authoritative bodies to gain trust.
* **Continued Innovation:** There are still some CPR quality parameters that are hard to measure with wearables – for example, effective ventilation during CPR (for those not doing Hands-Only CPR) or the quality of airway management. Future wearables might integrate additional sensors (for instance, a headset to measure ventilation timing, or an adhesive sensor on the patient to gauge recoil more directly). Additionally, haptic feedback (vibrations on the rescuer’s hands or fingers) is an emerging modality that could supplement audio/visual cues in noisy environments. Researchers are also exploring AI-driven feedback, which could adapt prompts in real time to the situation (e.g., encouraging a faster pace if it detects slowing down, or warning when fatigue likely sets in).

In conclusion, the literature from the last decade paints an optimistic picture: **wearable CPR feedback devices and mobile health technologies can significantly enhance the chain of survival** for cardiac arrest victims. High-impact studies have demonstrated improved CPR performance metrics with feedback gloves, smartwatches, and other devices, while community trials show mobile apps getting more people to perform CPR and use AEDs, ultimately saving lives. The gap between recommended CPR quality and what is actually delivered by lay rescuers is increasingly being narrowed by these technological aids. As Musiari et al. (2021) showed, even individuals with no healthcare background can perform near-professional-quality CPR when guided by a smart device on their hand. This is a profound finding – it suggests that with the right support tools, the general public’s capacity to act in cardiac emergencies can be dramatically improved.

Still, challenges of device adoption, cost, and integration remain. But given the fast pace of innovation and the strong push from organizations like the AHA (which explicitly calls for improved CPR monitoring and feedback solutions), it is likely that the coming years will see these wearable technologies move from the lab and limited trials into mainstream use. The ultimate goal driving all this research is to improve survival and neurological outcomes from cardiac arrest. By empowering rescuers with real-time feedback and connecting them swiftly to AEDs and help, the chances of survival can be significantly increased. The literature review clearly identifies that **the technology is maturing**; the next steps will involve large-scale implementation and rigorous outcome evaluations to truly validate the life-saving impact of wearable CPR feedback devices in real-world scenarios.

**Summary of Key Studies and Sources**

* **Kang & Exworthy (2022)** – *JMIR mHealth and uHealth*: Scoping review of wearable health technology. Concluded that wearables empower users in health management by aiding diagnosis, self-monitoring, and behavior change[pubmed.ncbi.nlm.nih.gov](https://pubmed.ncbi.nlm.nih.gov/35830222/#:~:text=Conclusions%3A%20%20Considerable%20literature%20findings,including%20promotion%20and%20support%20from). Highlights the broad potential of wearables in healthcare beyond just clinical settings.
* **Eiri et al. (2025)** – *PLOS ONE*: Developed the “Local DEA” AED locator app in Brazil. The app provides geolocation of AEDs, navigation, and CPR instructions. Expert evaluation showed high usability, and simulations indicated the app can significantly reduce time to defibrillation when AEDs are well-positioned, thereby potentially improving survival in out-of-hospital cardiac arrest.
* **Hu et al. (2025)** – *BMC Health Services Research*: Systematic review and meta-analysis of mobile responder apps for cardiac arrest (13 studies). Found that mobile alert systems increased bystander CPR and AED use rates and improved survival to hospital discharge by ~34% compared to EMS alone. Validates the effectiveness of smartphone activation of lay rescuers in improving outcomes.
* **Musiari et al. (2021)** – *Frontiers in Cardiovascular Medicine*: Tested a CPR coaching glove with visual/vocal feedback on 130 laypeople. In a controlled trial, the glove significantly improved compression rate maintenance (keeping ~118/min vs 103/min without) and reduced depth decay (nearly eliminating fatigue-related decline). Concludes that a wearable glove coach is effective in guiding untrained rescuers to perform better CPR.
* **Kahsay et al. (2025)** – *Journal of Cardiovascular Nursing*: Evaluated the **ResuGlove** (soft sensor-embedded glove) in a randomized crossover manikin study with 29 trained students. While average depth/rate were similar, the glove feedback led to a much higher proportion of compressions in the correct depth (83% vs 41%) and rate (97% vs 72%) ranges. The glove also improved complete recoil and had acceptable usability. Demonstrates the benefit of a flexible wearable on CPR quality and user comfort.
* **Guridi et al. (2024)** – *IEEE Access*: Presented a proof-of-concept smart CPR glove with e-textile pressure sensors and IMUs. The glove accurately measured depth, rate, recoil, and pauses in real time[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=quality%20of%20compressions,compression%20depth%2C%20compression%20rate%2C%20chest). Authors noted the glove is lightweight and adaptable, offering an alternative to hard devices[researchgate.net](https://www.researchgate.net/publication/377944312_A_Proof-of-Concept_Study_on_Smart_Gloves_for_Real-Time_Chest_Compression_Performance_Monitoring#:~:text=,wearable%20devices%20in%20healthcare%20settings). This study confirmed the technical feasibility and accuracy of a textile-based wearable for CPR feedback.
* **Lim et al. (2021)** – *Biosensors*: Developed a **smart-ring** CPR feedback device using an IMU. The ring’s depth measurements had very low error (~1–2 mm) in tests, showing it can reliably gauge compression depth. Compared to smartphone and smartwatch placements, the ring (worn on the finger) can be more directly aligned with the compression axis. Proposed as an ultra-compact solution for depth feedback in both adult and infant CPR.
* **Lu et al. (2019)** – *Resuscitation*: RCT on a smartwatch CPR feedback app with 80 healthcare professionals. Found that without feedback, compressions were too fast and shallow (avg 129/min, 39 mm), but with the smartwatch feedback, quality improved to ~112/min and 51 mm depth. The percentage of high-quality compressions was significantly higher in the feedback group. Concludes that real-time feedback via a wearable device markedly improves CPR delivered by rescuers.
* **Song et al. (2016)** – *Resuscitation*: Feasibility study of using smartwatches as compression feedback tools. Demonstrated that a smartwatch accelerometer could detect compressions and provide guidance tones. Though a small study, it opened the door to considering consumer wearables for CPR. Noted that while feasible, attention to the user interface (minimizing need to check the watch) is important.
* **Park et al. (2014)** – *Technology and Health Care*: Investigated a smartphone app for CPR feedback versus standard CPR. While the app improved compression depth maintenance, many users reported discomfort and hand pain when using the phone as a feedback device. This study is frequently cited to illustrate the ergonomic problems with phone-based CPR aids and the need for more user-friendly designs (like wearables).
* **Perkins et al. (2005)** – *Resuscitation*: Evaluated the CPREzy feedback device on a manikin. It improved compression depth significantly, but **95% of users experienced heel-of-hand pain** from the rigid device. One user had a minor injury. Highlights the trade-off observed in early feedback devices: better CPR quality at the cost of rescuer comfort.
* **Elding et al. (1998)** – *Resuscitation*: Studied the CPR-Plus device. Showed improved technique, but about 20% of participants felt wrist/hand discomfort with the device during extended use. As one of the first feedback tool studies, it provided proof that feedback helps but also pointed out user fatigue issues.
* **Hong et al. (2016)** – *Resuscitation (Letter)*: Reported on injuries caused by feedback device use (CPRmeter) during CPR training. Noted nearly 39% of trainees had hand bruises or pain after using the CPRmeter. This letter to the editor underscored that even well-established devices can have side effects, reinforcing the need for **softer, more ergonomic solutions**.

Each of these studies contributed to understanding the landscape of CPR aids – from early rigid devices to modern wearables and mobile apps. Together, they show a clear trajectory toward devices that are **integrated into what rescuers wear or carry**, providing necessary guidance with minimal downsides. The references listed above (all peer-reviewed journal publications) form a solid evidence base for the benefits of feedback technology in resuscitation, as well as the considerations for future improvements in this field.

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