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Technology-enabled health promotion and disease prevention: a review of mobile computing, sensing, and information systems

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ABSTRACT

Digital technologies are increasingly transforming health promotion and disease prevention by enabling health information to be collected, communicated, and used beyond conventional healthcare facilities. Mobile computing, wearable sensors, communication networks, and health information systems provide opportunities to support preventive interventions, monitor health-related behaviors, and improve access to health services. This review examines the technological foundations, major applications, and implementation challenges of technology-enabled health promotion and disease prevention, drawing on literature published up to 2013. Particular attention is given to mobile devices, physiological and activity sensors, short message service (SMS) interventions, mobile applications, and information systems supporting individual and population health activities. Applications in physical activity promotion, smoking cessation, medication adherence, maternal and child health, and community-based health services are discussed. The review also considers the roles of data integration, personalized feedback, usability, privacy, and evaluation in determining intervention effectiveness. Although mobile and sensing technologies offer promising mechanisms for encouraging healthier behaviors and supporting preventive care, their effectiveness cannot be assumed from technological availability alone. Sustainable implementation requires evidence-based intervention design, appropriate information infrastructure, user engagement, and integration with existing public health services.

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1. INTRODUCTION

Health promotion and disease prevention are essential components of public health because they address health risks before these risks develop into serious medical conditions. Traditional approaches rely on healthcare education, community programs, screening activities, and direct interaction between health professionals and individuals. Digital technologies provide additional mechanisms for delivering health information, monitoring behavior, and supporting preventive activities across different environments.

Mobile computing, sensing technologies, and health information systems have expanded the opportunities for technology-enabled prevention. Mobile phones can deliver health messages and reminders, wearable sensors can measure physical activity and selected physiological parameters, and information systems can organize data for healthcare providers and public health organizations. These capabilities allow health interventions to move beyond scheduled clinical encounters and become more closely connected to everyday activities [1], [2].

However, technological availability does not automatically produce better health outcomes. Effective interventions require appropriate behavioral strategies, reliable measurements, accessible communication, and integration with healthcare services. This review examines the technological foundations and applications of these systems while considering their limitations and implications for public health.

2. MOBILE COMPUTING FOR HEALTH PROMOTION

Mobile computing provides a practical platform for delivering preventive health information and supporting communication between individuals and healthcare services. Smartphones and conventional mobile phones can deliver educational messages, reminders, questionnaires, and personalized feedback through applications, text messages, and Internet-based services. These capabilities make mobile technology particularly relevant to interventions that require frequent communication or repeated engagement [1], [3].

2.1. Mobile messaging and behavioral interventions

Short message service (SMS) is one of the simplest and most accessible mobile technologies for health promotion. It can provide reminders about medication use, vaccination schedules, screening appointments, healthy diets, and physical activity. Research on mobile messaging has examined its potential to support preventive healthcare and encourage health-related behavioral changes, although effectiveness varies according to intervention design and target behavior [4].

Mobile messaging can also support smoking cessation, treatment adherence, and communication between patients and healthcare providers. Messages may be scheduled, tailored to individual needs, or triggered by specific events. Nevertheless, repeated messages can become ineffective when their content is irrelevant, their frequency is excessive, or users lose interest over time.

2.2. Mobile applications and self-management

Mobile applications extend the functions of basic messaging by integrating educational content, self-monitoring, goal setting, and feedback. Users can record physical activity, dietary habits, body weight, and other health-related behaviors through interactive interfaces. These functions can help individuals recognize behavioral patterns and monitor progress toward preventive health goals [2], [5].

The effectiveness of mobile applications depends on their ability to support sustained engagement and meaningful behavior change. User-friendly interfaces, relevant content, appropriate feedback, and alignment with behavioral theories are important design considerations. Human–computer interaction therefore plays an important role in determining whether mobile health interventions are understandable, acceptable, and practical for their intended users [6].

3. SENSING TECHNOLOGIES AND HEALTH ASSESSMENT

Sensing technologies provide objective information about physical activity and selected physiological conditions. Wearable devices, accelerometers, pedometers, heart-rate monitors, and other physiological sensors can collect data during everyday activities. Their integration with mobile devices creates opportunities to connect behavioral assessment with preventive interventions [2], [5].

3.1. Physical activity and lifestyle monitoring

Physical activity monitoring is an important application of mobile sensing because physical inactivity is associated with several chronic health risks. Accelerometers and pedometers can measure movement, estimate activity levels, and provide feedback about daily exercise patterns. When connected to mobile applications, these devices can support personal goals, reminders, and activity-based interventions [5].

Mobile sensing can also help researchers and healthcare professionals observe behavior in natural environments rather than relying exclusively on retrospective questionnaires. Repeated measurements may provide more detailed information about daily activity patterns and behavioral changes. However, sensor accuracy, device placement, missing data, and differences in measurement methods must be considered when interpreting results [1], [5].

3.2. Physiological and contextual monitoring

Wearable sensors can measure selected physiological parameters such as heart rate, body temperature, and other indicators relevant to health assessment. Mobile devices can combine these measurements with self-reported information and contextual observations to provide a broader understanding of individual health behavior. Such integration creates opportunities for preventive interventions that respond to both physiological conditions and daily activities [1], [2].

Nevertheless, sensor-derived measurements should not be treated as definitive clinical diagnoses. Devices may produce inaccurate readings because of movement, environmental interference, calibration problems, or individual physiological differences. Appropriate validation and clinical interpretation are therefore necessary before sensor information is used to guide health decisions.

4. HEALTH INFORMATION SYSTEMS AND DATA INTEGRATION

Health information systems provide the infrastructure for collecting, storing, processing, and sharing information generated by mobile and sensing technologies. These systems can connect individuals, healthcare providers, community health workers, and public health organizations through shared information platforms. Their integration supports continuity of information and can improve the coordination of preventive health activities [7], [8].

4.1. Individual and community health information

At the individual level, information systems can organize measurements, health records, reminders, and intervention histories. Healthcare professionals may use these records to review patient progress and identify individuals who require additional attention. At the community level, mobile systems can support field-based data collection, health education, reporting, and communication between community health workers and healthcare facilities [7].

4.2. Population health and public health surveillance

Information systems can also support public health organizations by improving the availability and exchange of health-related information. Electronic health records and health information exchange can contribute to automated reporting and notifiable disease surveillance. These capabilities demonstrate that digital health infrastructure can support both individual preventive services and broader population-level public health activities [8].

However, information integration requires consistent data definitions, compatible formats, appropriate access controls, and reliable information governance. Fragmented systems may create duplicated records, incomplete information, and difficulties in interpreting data across organizations. Interoperability should therefore be considered a fundamental requirement rather than an optional technical feature.

5. APPLICATIONS IN HEALTH PROMOTION AND DISEASE PREVENTION

Technology-enabled interventions have been applied to several preventive health activities, particularly those involving behavior change and regular communication. Physical activity promotion, smoking cessation, medication adherence, and maternal and child health services are examples of areas where mobile technologies have been investigated. Their value depends on the relationship between the technological intervention, the targeted behavior, and the health service responsible for implementation [3], [4], [7].

Physical activity interventions may combine mobile messaging, self-monitoring, and wearable sensors to encourage individuals to become more active. Smoking cessation and medication adherence programs may use scheduled messages and personalized support to reinforce behavioral goals. Maternal and child health programs can use mobile devices to provide health information, support community health workers, and improve communication with healthcare facilities [3]-[5], [7].

These applications demonstrate the flexibility of mobile technologies, but the evidence of effectiveness is not uniform. Reviews of mobile health interventions have identified promising results in selected areas while also emphasizing limitations in study quality, intervention design, and outcome measurement. Technology should therefore be evaluated according to its demonstrated contribution to health outcomes rather than the number of devices, messages, or application features deployed [1], [2].

6. CHALLENGES AND IMPLEMENTATION CONSIDERATIONS

Successful implementation requires more than reliable devices and communication infrastructure. Digital literacy, affordability, network availability, accessibility, and user acceptance can influence whether individuals benefit from technology-enabled health programs. These factors are particularly important in rural and low-resource settings, where infrastructure and technical support may be limited [7].

Privacy and information security are also essential considerations. Mobile devices and connected information systems may collect sensitive personal, behavioral, and physiological information that requires appropriate protection. Data confidentiality, informed consent, secure transmission, and controlled access should be incorporated into the design and management of preventive health platforms.

Another challenge is demonstrating that technology produces meaningful improvements in health. Evaluation should consider behavioral changes, clinical outcomes, intervention adherence, user experience, and cost-effectiveness. The mHealth evidence literature emphasizes the need for rigorous evaluation to determine which interventions work, for whom, and under what circumstances [1].

7. FUTURE DIRECTIONS

Future development should emphasize the integration of mobile computing, sensing, and information systems into coordinated preventive health services. More effective combinations of self-monitoring, personalized feedback, and context-aware communication may improve the relevance of interventions. However, personalization should be based on reliable information and appropriate behavioral principles rather than technological complexity alone.

Health information systems should also become more interoperable and responsive to the needs of individuals, healthcare professionals, and public health organizations. Stronger integration may support continuous preventive care and improve the use of information for community health planning. Future evaluation should place greater emphasis on long-term behavioral outcomes, equitable access, and the sustainability of technology-enabled interventions.

8. CONCLUSION

Mobile computing, sensing technologies, and health information systems provide complementary capabilities for advancing health promotion and disease prevention. Mobile devices support communication and behavioral interventions, sensors enable monitoring of activity and physiological conditions, and information systems organize data for individual care and population health activities. Despite their potential, successful implementation depends on evidence-based intervention design, usability, privacy, interoperability, equitable access, and rigorous evaluation. Technology-enabled prevention should therefore be developed as an integrated component of public health services rather than as a collection of independent digital tools.

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