# Health information technologies in geriatrics and gerontology: a mixed systematic review

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## ABSTRACT

**Objective** To review, categorize, and synthesize findings from the literature about the application of health information technologies in geriatrics and gerontology (GGHIT).

**Materials and Methods** This mixed-method systematic review is based on a comprehensive search of Medline, Embase, PsychInfo and ABI/Inform Global. Study selection and coding were performed independently by two researchers and were followed by a narrative synthesis. To move beyond a simple description of the technologies, we employed and adapted the diffusion of innovation theory (DOI).

**Results** 112 papers were included. Analysis revealed five main types of GGHIT: (1) telecare technologies (representing half of the studies); (2) electronic health records; (3) decision support systems; (4) web-based packages for patients and/or family caregivers; and (5) assistive information technologies. On aggregate, the most consistent finding proves to be the positive outcomes of GGHIT in terms of clinical processes. Although less frequently studied, positive impacts were found on patients' health, productivity, efficiency and costs, clinicians' satisfaction, patients' satisfaction and patients' empowerment.

**Discussion** Further efforts should focus on improving the characteristics of such technologies in terms of compatibility and simplicity. Implementation strategies also should be improved as trialability and observability are insufficient.

**Conclusions** Our results will help organizations in making decisions regarding the choice, planning and diffusion of GGHIT implemented for the care of older adults.

## BACKGROUND AND SIGNIFICANCE

Health information technology (HIT) has the potential to improve the access, quality, safety and efficiency of patient care.[1 2] The use of HIT may be particularly helpful in the care of older patients.[3] Older patients often have multiple acute and chronic problems that require ongoing management by a variety of medical professionals in a variety of settings.[4] Advanced age, the need for assistance with activities of daily living, and multiple active chronic illnesses place the older adult at greatest risk of poor-quality care and suboptimal transition between care settings.[5 6] The large size and accelerating growth of the community-dwelling dependent population, together with growing expectations for patient-centered services, are creating a need for the development and use of new information technologies.[4 7 8]

A review of integrated/transitional care and hospital-at-home models reveals that many models of care for older adults have a HIT component.[9 10] Studies have shown that HIT has certain well-known benefits such as improved quality and efficiency of care.[1] However, there are also studies suggesting adverse results.[11 12] Furthermore, the diffusion of HIT is occurring very slowly, adoption rates are low and there have been implementation failures.[13 14]

Many different approaches to developing and implementing health information technologies in geriatrics and gerontology (GGHIT) have been documented in the literature, but to our knowledge, there has been no attempt to synthesize the information in these published studies. Such a synthesis may provide guidance on strategies for the successful implementation of GGHIT. In this paper we present a mixed systematic review of GGHIT. The specific objectives of this review are: (1) to provide a typology of the different applications of GGHIT; (2) to determine both the positive and negative outcomes of various applications of GGHIT; and (3) to identify the factors that contribute to or hinder the successful implementation of specific GGHIT.

## METHODS

### Design

A mixed method systematic review,[15] in which evidence extracted from different sources is integrated to identify patterns and directions in the findings, was undertaken because it is particularly appropriate for understanding complex phenomena such as the adoption of innovations.[16 17] This method, recognized by the Cochrane Collaboration for systematic reviews of intervention,[18] can determine the effectiveness — or lack thereof — of different interventions and the conditions for their success or failure.[17 18] The mixed review is presented according to PRISMA criteria:[19] (1) eligibility criteria; (2) information source and search strategy; (3) study selection; (4) data collection process and synthesis of results; and (5) critical appraisal.

### Eligibility criteria

The studies that met the inclusion criteria were those that reported on the assessment of GGHIT, and reported factors influencing the implementation of GGHIT. In the review, we considered all types of GGHIT, including HIT with low technical characteristics such as telephones. Articles were excluded if they were focused solely on describing the design or development of GGHIT or dealt with educational technologies.

### Information sources and search strategy

The review is based on a systematic, comprehensive search of four databases: Medline, Embase, PsychInfo and ABI/Inform Global. Articles in English or French, published or in press between January 2000 and April 2010, were considered. The literature search was performed by a librarian and validated by a researcher. The following two sets of keywords and terms were searched in combination:

- Information technology (Information Technology; Medical Informatics; Computers; Medical Records Systems; Medical Informatics; Hospital Information Systems; Internet; Local Area Networks; Telemedicine; Educational Technology; Information Systems; Automated Information Processing; Computer Applications; Computer Mediated Communication; Electronic Communication)
- Geriatrics/Gerontology (Geriatrics; Geriatric Dentistry; Geriatric Nursing; Geriatric Psychiatry; Geriatric Assessment; Geriatric Patients; Older patients; Gerontology)

We hand-searched the reference lists of all the selected references. EndNote software was used to manage the references and eliminate duplications.

### Study selection

Study selection was performed independently by two researchers. First, references were selected based on title and abstract according to the review study's inclusion and exclusion criteria. When there was any doubt, the study was provisionally included for consideration on the basis of a reading of the full text. The second round of selection was based on the full text of the papers. Any disagreement was resolved through consensus by two other researchers. Kappa scores were calculated at each stage (see figure 1).

### Data collection and synthesis

Data extraction from the selected studies was performed independently by two researchers using a standardized form.

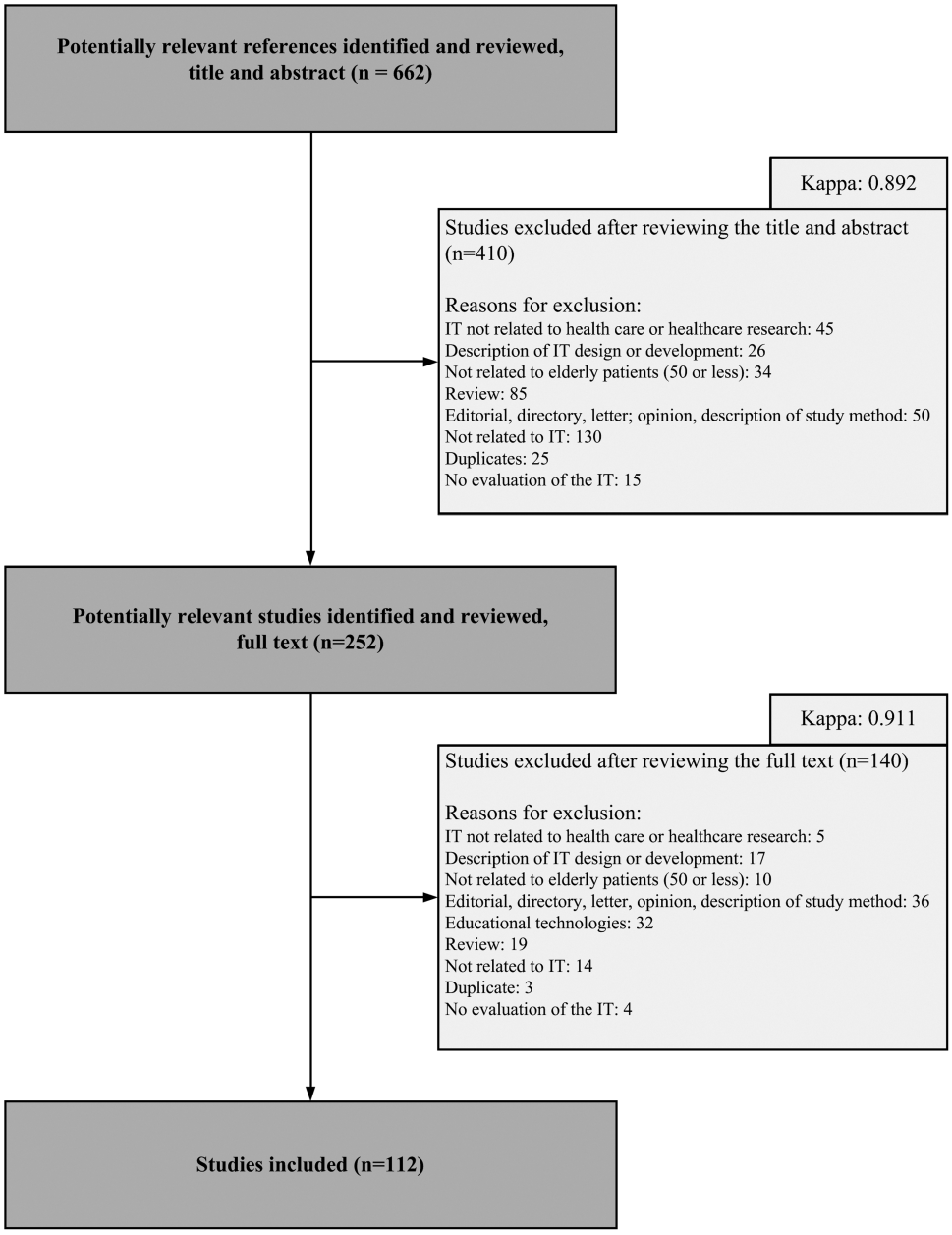


**Figure 1** Flow chart.

To synthesize data, we first conducted a narrative synthesis of the heterogeneity of study characteristics.[20] We used the validated methodological guide for narrative syntheses,[20] which allowed us to first develop a typology of GGHIT by creating homogeneous subgroups.[20] Our analysis goes beyond the denomination of these GGHIT used by the studies' authors. First, it encompasses the technologies' critical characteristics: functionalities, potential users (stakeholder clinicians or patients), and rationales in terms of the processes that the GGHIT are intended to support/improve. Second, we analyzed our results using the diffusion of innovation theory (DOI).[21] This theory states that the DOI process is influenced by five characteristics of the innovation:[21] relative advantage (the degree to which an innovation is perceived as better than the idea it supersedes), compatibility (the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters), simplicity (the degree to which an innovation is perceived as not difficult to understand and use), trialability (the degree to which an innovation may be experimented with on a limited basis) and observability (the degree to which the results of an innovation are understandable to individuals or known by the community). In order to move beyond a simple description of the technologies, we refined the DOI framework and created three categories that allowed us to differentiate between the technology per se, its implementation and its specific outcomes. In the data collection and synthesis phase, any disagreement was resolved through consensus.

### Critical appraisal

The methodological quality of the studies was assessed independently by two researchers. As the methods of the included studies were disparate—qualitative, quantitative, or mixed—we used all nine criteria of a quality assessment tool developed for systematic reviews of disparate data.[22] Once again, any discrepancies were resolved through consensus. No study was excluded on the basis of its quality, as our primary objective was to gain knowledge on the nature of GGHIT. However, we conducted a sensitivity analysis[18] in order to assess whether the decision to include each study independent of its quality had a major effect on the results of the review.

## RESULTS

The primary search yielded 658 references (figure 1). Another four references were found by searching the reference lists of the retrieved articles (N=662). Applying the inclusion and exclusion criteria, 410 references were excluded on the basis of the title and abstract (κ 0.89) and 140 were excluded on the basis of the full text (κ 0.91). The final sample consisted of 112 articles.

### Characteristics of the selected studies

Fifty-seven per cent of the studies were conducted in North America—USA (53%) and Canada (4%)—and one in South America (1%) (see supplementary appendix 1, available online only). The remaining studies were conducted in Europe (20%), Asia (13%) and Oceania (8%). Two studies were conducted in multiple countries (2%). Most of the study designs were quantitative (61%). Of these, only 13% were based on a randomized controlled trial. Other quantitative designs were quasi-experimental design (27%), observational study (14%) or survey (6%). The rest of the studies employed qualitative (32%) or mixed method designs (7%).

The settings were mainly patients' homes (38%), long-term care facilities (22%), hospitals (21%), medical centers (5%), universities (1%) and multiple sites (10%). The subjects were only patients (68%), both patients and professionals (14%), or multiple healthcare professionals (10%).

### Typology of GGHIT

The analysis of the literature revealed five types of GGHIT (described in table 1). While telecare technologies are the focus of exactly 50% of the selected articles,[23–77] other GGHIT were less frequently studied: electronic health records (EHR) (12.5% of the selected articles),[78–91] decision support systems (DSS) (13.4%),[92–106] web-based packages for patients/family caregivers (11.6%),[107–119] and assistive information technologies (12.5%).[120–133]

### Methodological quality of the studies

The critical appraisal of the studies selected in our review reveals that the robustness of the research methods used in gerontology and geriatrics for studying health informatics varies across studies (table 2). Indeed, weaknesses were observed in the descriptions of methods, particularly a lack of detailed information on the sampling methods used (assessed as fair, poor or not reported in 67% of the studies) and on the data analysis (assessed as fair, poor or not reported in 60% of the studies). Furthermore, the studies rarely report on ethical aspects and risks of bias. The research findings and results and the implications and usefulness of the studies were rated as good or fair in 94% and 88% of the studies, respectively.

We also performed the critical appraisal for each type of GGHIT (see supplementary appendix 2, available online only). The results show that the quality of the studies is similar from one type of GGHIT to another, except that method/data and sampling were rated as 'good' in studies involving DSS slightly more often than studies involving other types of GGHIT.

In addition, a sensitivity analysis[19] was conducted to determine whether the decision to include all the studies, independent of their overall quality, had any effect on the results of the review. Even when we excluded the articles with at least one bad quality indicator (eg, rated as very poor or not reported with regard to methods and data, sampling, data analysis), the findings of this review remained consistent.

### Outcomes, technology and implementation of GGHIT

#### Global results

As the study results in table 3 show, on aggregate, GGHIT translate into positive outcomes. Impact on clinical processes was the outcome most frequently studied and almost all of the 65 studies that looked at it had positive results (94%). Only 25 studies examined impacts on patients' health outcomes, of those 96% reported a positive outcome. Similarly, 27 out of 33 studies (82%) that looked at patients' satisfaction had positive results. Although examined even less frequently, impacts were mainly positive in terms of productivity, efficiency and costs (14/16 studies; 88%), clinicians' satisfaction (11/13; 85%), and patients' empowerment (12/15; 80%).

Despite these positive impacts, there is still room for improvement regarding the characteristics of technology: GGHIT are not always compatible with the values, professional practices, and needs of patients and clinicians (positive compatibility in 62% of the 42 studies), and only 55% of the studies (22/40) found that GGHIT are considered simple to use.

Furthermore, in terms of implementation, the results demonstrate that while 17 out of 22 studies that looked at this issue found positive results (77%), trialability (often reflected as technical support, training and adaptation) is still insufficient. It is

**Table 1** Typology of HIT used in gerontology and geriatrics

| Type of HIT N=112 | Core functionalities | Rationale–goals–potential interest | Other denominations |
|---|---|---|---|
| Telecare 56 articles (50%) | Enables remote diagnoses, monitors patient health status, provides case management or rehabilitation | ▶ Shift in care from hospitals to ambulatory settings<br>▶ Response to the shortage of professionals<br>▶ Decreased impact of remoteness<br>▶ Availability of medical and specialized expertise<br>▶ Improved working conditions<br>▶ Avoidance of clinician travel time<br>▶ Optimal use of nurses' time | Teleconsultation, telemonitoring, remote case management, telerehabilitation |
| EHR 14 articles (12.5%) | Provides a structured repository of patient medical information generated by one or more encounters—without a decision-support system | ▶ Access to patient information<br>▶ Collaboration and coordination among team members<br>▶ Access to patient information from multiple locations<br>▶ Database of structured and complete information<br>▶ Patient self-management | EHR, electronic nursing record, computerized patient care record, electronic medical record, personal health records, electronic geriatric assessment tools, e-prescribing, computer generated reports/ summaries, chronic disease registries without DSS |
| DSS 15 articles (13.4%) | Guides healthcare professionals in their decision making | ▶ Better quality and safety of care (eg, avoiding adverse drug events)<br>▶ Avoidance of failures to apply evidence-based medicine<br>▶ Standardized care | Electronic reminders/alerts, computerized order entry with DSS, computerized monitoring of drug levels, electronic guidelines, electronic care plan development, chronic disease registries with DSS (reminders, computerized clinical guidelines, ordering guidance, etc) |
| Web-based packages and social media for patients/family caregivers 13 articles (11.6%) | Provides health information/support for patients/family caregivers by telephone, telecomputing, web-based information | ▶ Access to scientific information<br>▶ Patient self-management<br>▶ Increased coping strategies<br>▶ May break isolation<br>▶ Alleviate family burden and anxiety | Web-based health information, health web sites, e-health web portals, caregiver support online |
| Assistive information technology 14 articles (12.5%) | Helps an individual to perform a task safely | ▶ Independent living for elderly people<br>▶ Access to assistance for patients in the context of insufficiently available human/financial resources<br>▶ Improved safety<br>▶ Improved quality of life, well-being for patients | Smart home, gerontechnology, domotics, robotic technology (service/assistant robots, robotic pets), automated pill dispensers, PDA |

DSS, decision support systems; EHR, electronic health records; HIT, health information technology; PDA, personal digital assistant.

also the case for observability (positive for 3/5 studies—60%), which has rarely been studied. The following subsections provide a closer examination of these results for each of the five types of GGHIT identified earlier. Tables 4–8 provide finer-grained information for each dimension.

### Telecare technologies

A vast majority of studies evaluated the outcomes of telecare technologies (table 4) as positive in terms of clinical processes (31/32; 97%), patients' health outcomes (15/15; 100%), productivity, efficiency and costs (11/12; 92%), clinicians' satisfaction (7/7; 100%), patients' satisfaction (16/21; 76%) and patients' empowerment (6/6; 100%).[23–77 107] In terms of the technology, compatibility was positive in 76% of the studies (16/21). However, telecare technologies were perceived as easy to use in less than half of the studies (9/19; 47%). Regarding

**Table 2** Critical appraisal of the studies N (%)

| | Good | Fair | Poor | Very poor | NA | NR |
|---|---|---|---|---|---|---|
| Abstract | 84 (75) | 28 (25) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Introduction and aims | 64 (57) | 48 (43) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Method and data | 56 (50) | 45 (40) | 9 (8) | 1 (1) | 0 (0) | 1 (1) |
| Sampling | 35 (31) | 41 (37) | 24 (21) | 0 (0) | 2 (2) | 10 (9) |
| Data analysis | 45 (40) | 48 (43) | 11 (10) | 0 (0) | 0 (0) | 8 (7) |
| Ethics and bias | 34 (30) | 2 (2) | 1 (1) | 0 (0) | 0 (0) | 75 (67) |
| Findings/results | 44 (39) | 61 (55) | 7 (6) | 0 (0) | 0 (0) | 0 (0) |
| Transferability/ generalizability | 32 (29) | 65 (58) | 15 (13) | 0 (0) | 0 (0) | 0 (0) |
| Implications and usefulness | 33 (30) | 65 (58) | 14 (12) | 0 (0) | 0 (0) | 0 (0) |

NA, not applicable; NR, not reported.

**Table 3** Summary of the results (N=112 studies; N (%))

| Dimensions | Not reported | N* | + | – | +/– | Ø |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes | 47 | 65 (100) | 61 (94) | 3 (5) | 0 (0) | 1 (1) |
| Patients' health outcomes | 87 | 25 (100) | 24 (96) | 1 (4) | 0 (0) | 0 (0) |
| Productivity, efficiency, costs | 96 | 16 (100) | 14 (88) | 1 (6) | 0 (0) | 1 (6) |
| Clinicians' satisfaction | 99 | 13 (100) | 11 (85) | 2 (15) | 0 (0) | 0 (0) |
| Patients' satisfaction | 79 | 33 (100) | 27 (82) | 5 (15) | 0 (0) | 1 (3) |
| Patients' empowerment | 97 | 15 (100) | 12 (80) | 1 (7) | 0 (0) | 2 (13) |
| Technology | | | | | | |
| Compatibility | 70 | 42 (100) | 26 (62) | 14 (33) | 2 (5) | 0 (0) |
| Simplicity | 72 | 40 (100) | 22 (55) | 10 (25) | 8 (20) | 0 (0) |
| Implementation | | | | | | |
| Trialability | 90 | 22 (100) | 17 (77) | 3 (14) | 2 (9) | 0 (0) |
| Observability | 107 | 5 (100) | 3 (60) | 2 (40) | 0 (0) | 0 (0) |

N*, Number of studies for which the dimension was evaluated; +, positive evaluation; –, negative evaluation; +/–, evaluation that was both positive and negative; Ø, no influence.

**Table 4** Synthesis of the results for telecare technologies (56 studies;[23–77 107] N(%))

| | N* | + | – | +/– | Ø | Examples |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes[23 30 32–45 47 50 52 56 57 60–62 64–66 71–74 77] | 32 (100) | 31 (97) | 1 (3) | 0 (0) | 0 (0) | + Increased quality of care, continuity, timely access; improved uptake of preventive care, assessment and monitoring; decreased errors<br>– Failure to take into account complex cases |
| Patients' health outcomes,[25–29 41 42 55 56 59 63 66 68 73 107] | 15 (100) | 15 (100) | 0 (0) | 0 (0) | 0 (0) | + Improved blood test results, functional/cognitive autonomy, quality of life; decreased mortality |
| Productivity, efficiency, costs[30 33 36 37 45 52 56 62 63 69 71 76] | 12 (100) | 11 (92) | 0 (0) | 0 (0) | 1 (8) | + Decreased emergency department visits and hospitalization; cost savings; decreased physician time; increased number of patients cared for |
| Clinicians' satisfaction[39 46 52 55 63 71 76] | 7 (100) | 7 (100) | 0 (0) | 0 (0) | 0 (0) | + The clinicians are highly satisfied; viewed favorably and highly acceptable |
| Patients' satisfaction[24 28 31 33 35 36 39 41 46–49 51–55 60 66 70 76] | 21 (100) | 16 (76) | 5 (24) | 0 (0) | 0 (0) | + Increased sense of personal safety and security; increased user satisfaction; patients preferred a remote interview close to their homes to an in-person interview at a distance; patients perceived the system as a valuable resource that offered great potential<br>– Obtrusiveness; lack of user friendliness; inaccurate measurement; threat as a replacement for visits; interference with daily activities; privacy concerns |
| Patients' empowerment[26 28 41 67 77 107] | 6 (100) | 6 (100) | 0 (0) | 0 (0) | 0 (0) | + Self-confidence; self-efficacy |
| Technology | | | | | | |
| Compatibility[24 35 38 41 42 46–48 51 54 55 60 66 68 70 71 73–77] | 21 (100) | 16 (76) | 4 (19) | 1 (5) | 0 (0) | + Compatible with the existing relationships between patients and clinicians; adapt well to the context; feasible; acceptable<br>– Poor fit with the patient's preference for face-to-face contact; not well suited to physically impaired persons; privacy issues |
| Simplicity[24 30 31 33 35 40 42 46–48 50 53 55 60 66 67 71 75 77] | 19 (100) | 9 (47) | 7 (37) | 3 (16) | 0 (0) | + Easy to use<br>– Technical difficulties and lack of user-friendliness; information overload |
| Implementation | | | | | | |
| Trialability[46 47 53 60 73 76 77] | 7 (100) | 7 (100) | 0 (0) | 0 (0) | 0 (0) | + The more that participants use it, the more comfortable they feel with it |
| Observability[35 70] | 2 (100) | 1 (50) | 1 (50) | 0 (0) | 0 (0) | + Observability is evaluated as positive<br>– Nurses' negative perception of the technology's aesthetics |

N*, Number of studies for which the dimension was evaluated; +, positive evaluation; –, negative evaluation; +/–, evaluation that was both positive and negative; Ø, no influence.

**Table 5** Synthesis of the results for EHR (14 studies;[78–91] N(%))

| | N* | + | – | +/– | Ø | Examples |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes[79 81–91] | 12 (100) | 11 (92) | 1 (8) | 0 (0) | 0 (0) | + Improved communication; increased accuracy of records; better detection and assessment; improved quality of care; decreased medication use<br>– Low timeliness of data reporting; lack of sensitivity to health status change |
| Patients' health outcomes[80] | 1 (100) | 1 (100) | 0 (0) | 0 (0) | 0 (0) | + Quality of life |
| Productivity, efficiency, costs[80 88] | 2 (100) | 2 (100) | 0 (0) | 0 (0) | 0 (0) | + Efficiency of resources use; cost saving |
| Clinicians' satisfaction[78 79 84 88] | 4 (100) | 2 (50) | 2 (50) | 0 (0) | 0 (0) | + Employee satisfaction; satisfaction regarding informational functionality of software<br>– Fax was the most preferred method for communication of discharge summaries; limited ability to comply with suggestions |
| Technology | | | | | | |
| Compatibility[84 88 90 91] | 4 (100) | 0 (0) | 3 (75) | 1 (25) | 0 (0) | – Poor ergonomics; loss of human contact; privacy issues |
| Simplicity[78 79 81 82 85 88] | 6 (100) | 3 (50) | 1 (17) | 2 (33) | 0 (0) | + Easy to use<br>– Difficulties may arise when using EHR; not user friendly; and technical problems; confusing |
| Implementation | | | | | | |
| Trialability[78 79 85 87 88 91] | 6 (100) | 3 (50) | 3 (50) | 0 (0) | 0 (0) | + Suitable technical support<br>– Insufficient or inadequate training; insufficient support |
| Observability[78 88 91] | 3 (100) | 2 (67) | 1 (33) | 0 (0) | 0 (0) | + Good observability<br>– Lack of awareness about EHR |

N*, Number of studies for which the dimension was evaluated; +, positive evaluation; –, negative evaluation; +/–, evaluation that was both positive and negative; Ø, no influence.
EHR, electronic health records.

implementation, all the seven studies that evaluated trialability had positive results. Results for observability were mixed (1/2 was positive).

### Electronic health records

In terms of outcomes, the synthesis of the selected studies (table 5) shows that EHR use led to positive impacts on clinical processes (11/12; 92%).[78–91] Other outcomes were studied less frequently but results were positive overall except for clinicians' satisfaction. Concerning the technology, EHR were found not to be compatible with current values, professional practices and needs of patients and clinicians in a majority of the studies (3/4; 75%). EHR were considered simple to use in only half of the studies (3/6; 50%). With regard to implementation, half of the studies gave a negative evaluation of trialability (3/6; 50%). Two out of three studies found observability to be positive (67%).

### Decision support systems

The majority of the studies (table 6) found that DSS led to positive outcomes regarding impacts on clinical processes (92% of the 12 studies for which this dimension was evaluated).[92–106] Other outcomes were studied less frequently but were generally positive except for productivity (1/2; 50%). Regarding the technology, most of the studies reported compatibility (3/5; 60%) and simplicity (3/5; 60%) for DSS. With regard to implementation, both studies that considered trialability were positive (100%). None of the studies evaluated the observability of DSS.

**Table 6** Synthesis of the results for DSS (15 studies;[92–106] N(%))

| | N* | + | – | +/– | Ø | Examples |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes[92–95 98 99 101–106] | 12 (100) | 11 (92) | 1 (8) | 0 (0) | 0 (0) | + Improved quality of care; decreased errors and adverse drug events; improved assessment and detection; improved communication<br>– Information content of the reminders |
| Patients' health outcomes[100] | 1 (100) | 1 (100) | 0 (0) | 0 (0) | 0 (0) | + Decreased mortality |
| Productivity, efficiency, costs[92 100] | 2 (100) | 1 (50) | 1 (50) | 0 (0) | 0 (0) | + Decreased hospital use; cost savings<br>– Increased time spent by physicians |
| Clinicians' satisfaction[92] | 1 (100) | 1 (100) | 0 (0) | 0 (0) | 0 (0) | + Satisfaction score with regard to clinical value |
| Patients' satisfaction[95–97] | 3 (100) | 3 (100) | 0 (0) | 0 (0) | 0 (0) | + Easy to understand and use; enjoyable to use |
| Technology | | | | | | |
| Compatibility[92 95 96 98 104] | 5 (100) | 3 (60) | 2 (40) | 0 (0) | 0 (0) | + Fits with current workflow<br>– Decreased clinical autonomy; time needed to read the reminders |
| Simplicity[92 95 96 98 101] | 5 (100) | 3 (60) | 1 (20) | 1 (20) | 0 (0) | + Easy to use<br>– Difficult to use; too many reminders; information content is complex |
| Implementation | | | | | | |
| Trialability[98 101] | 2 (100) | 2 (100) | 0 (0) | 0 (0) | 0 (0) | + Special modifications can be made to the software in response to the uniqueness of the setting |

N*, Number of studies for which the dimension was evaluated; +, positive evaluation; –, negative evaluation; +/–, evaluation that was both positive and negative; Ø, no influence.
DSS, decision support systems.

**Table 7** Synthesis of the results for web-based packages (13 studies;[108–120] N(%))

| | N* | + | – | +/– | Ø | Examples |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes[113 114 116] | 3 (100) | 2 (67) | 0 (0) | 0 (0) | 1 (33) | + Improved relationship with careers, families |
| Patients' health outcomes[109 111 120] | 3 (100) | 2 (67) | 1 (33) | 0 (0) | 0 (0) | + Decrease mental health problems<br>– Increase physical and mental health problems |
| Patients' satisfaction[112 113 120] | 3 (100) | 2 (67) | 0 (0) | 0 (0) | 1 (33) | + High interest in on-line health information |
| Patients' empowerment[108 110–112 114 115 117–119] | 9 (100) | 6 (67) | 1 (11) | 0 (0) | 2 (22) | + Confidence; self-efficacy; self-control<br>– Knowledge of how to search for information |
| Technology | | | | | | |
| Compatibility[108 112 115 119] | 4 (100) | 2 (50) | 2 (50) | 0 (0) | 0 (0) | + Compatibility is assessed positively<br>– Not compatible with patients' disabilities |
| Simplicity[115 119 120] | 3 (100) | 1 (33) | 1 (33) | 1 (33) | 0 (0) | + Easy to use<br>– Problems finding information; absence of a user's guide; language barriers |
| Implementation | | | | | | |
| Trialability[108 111 115 119] | 4 (100) | 2 (50) | 0 (0) | 2 (50) | 0 (0) | + Focus on new learner needs; access to an instructor; peer training assistants; support by a technical worker<br>– Insufficient time for exploration |

N*, Number of studies for which the dimension was evaluated; +, positive evaluation; –, negative evaluation; +/–, evaluation that was both positive and negative; Ø, no influence.

### Web-based packages for patients or family caregivers

The synthesis of the selected studies (table 7) shows that web packages for patients and/or family caregivers led to positive outcomes particularly with regard to patients' empowerment (6/9; 67%), which was most frequently studied.[108–120] The other outcomes were studied less frequently but were generally positive. In terms of the technology, compatibility received a positive evaluation in half of the four studies that looked into this issue (50%). The web packages were evaluated as easy to use in only one out of three studies (33%). In terms of implementation, trialability was found to be positive in two out of four studies (50%). None of the studies evaluated the observability of web packages.

### Assistive information technologies

A few studies for which outcomes were evaluated show that assistive information technologies (table 8) led to positive impacts on clinical processes (6/6; 100%), patients' health outcomes (5/5; 100%), clinicians' satisfaction (1/1; 100%) and patients' satisfaction (6/6; 100%).[121–133] In terms of the technology, the compatibility of assistive technologies received positive evaluation in most of the cases (5/8; 63%). Almost all the seven studies confirm that assistive devices are easy to use (6/7; 86%). In terms of implementation, three studies positively evaluated trialability (100%). None of the studies evaluated the observability of assistive information technologies.

## DISCUSSION

Our study identifies five major types of GGHIT, highlights their respective impacts as described in the literature, and offers a conceptual framework to understand better how these technologies are currently used and diffused. We believe that our use and adaptation of a sound theoretical foundation, the DOI theory increases the relevance and generalizability of our results in addition to facilitating the accumulation of knowledge over time.[135] We adapted DOI to frame our results into three categories. First, we identified the main outcomes of GGHIT in terms of their relative advantage. We further identified a subset of specific outcomes: impacts on clinical processes, patients' health outcomes, productivity, efficiency and costs, clinicians' satisfaction, patients' satisfaction and empowerment, which is responsive to researchers who 'have criticized the rather general nature of

**Table 8** Synthesis of the results for assistive information technologies (14 studies;[121–134] N(%))

| | N* | + | – | +/– | Ø | Examples |
|---|---|---|---|---|---|---|
| Outcomes | | | | | | |
| Clinical processes[121 122 124 125 127 130] | 6 (100) | 6 (100) | 0 (0) | 0 (0) | 0 (0) | + Improved assistance, detection of falls, monitoring of health parameters; increased communication; improved dietary intake |
| Patients' health outcomes[122 129 131 133 134] | 5 (100) | 5 (100) | 0 (0) | 0 (0) | 0 (0) | + Decreased agitation, depression; increased communication; decreased pain |
| Clinicians' satisfaction[128] | 1 (100) | 1 (100) | 0 (0) | 0 (0) | 0 (0) | + Useful to manage patients' health conditions |
| Patients' satisfaction[121 126 127 129 131 132] | 6 (100) | 6 (100) | 0 (0) | 0 (0) | 0 (0) | + Patients enjoyed using PDA; non-obtrusiveness of technology; positive attitude towards system |
| Technology | | | | | | |
| Compatibility[122–127 129 130] | 8 (100) | 5 (63) | 3 (38) | 0 (0) | 0 (0) | + Acceptable; appropriate<br>– Privacy issues; bulky nature of the devices |
| Simplicity[121–124 127–129] | 7 (100) | 6 (86) | 0 (0) | 1 (14) | 0 (0) | + Easy to use<br>– Problems using the devices |
| Implementation | | | | | | |
| Trialability[123 127 128] | 3 (100) | 3 (100) | 0 (0) | 0 (0) | 0 (0) | + Training and adaptability of assistive technologies; the more that participants use the technology, the more comfortable they feel with it |

PDA, personal digital assistant.

relative advantage as being an aggregate of benefits, claiming that this makes the construct too vague to measure effectively'.[136] Second, we highlighted the principal characteristics of these GGHIT in terms of their compatibility with existing values and practices and their simplicity. Third, we identified the role of trialability and observability in facilitating the implementation process.[137]

Our systematic review reveals on the one hand that, when looking at relative advantage, the use of GGHIT translates into positive outcomes mostly with regard to clinical processes. For instance, EHR have been shown to improve the quality of care[83] with fewer total medications per patient,[79] improved patient histories and physical examination assessments,[81] and better documentation of patient health status.[91 92] Despite the fact that the following outcomes have not been extensively looked at, our study also reveals a positive, yet relatively less consistent, impact of GGHIT on patients' health outcomes, productivity, efficiency and costs, clinicians' satisfaction, patients' satisfaction and empowerment. For example, telecare technologies have been shown to improve health outcomes (health status or functional health)[27 28 41 63 66] and help in disease control,[59] and DSS have been found to increase clinicians' awareness of patient safety risks.[101] Overall, our systematic review indicates that GGHIT may play a critical role in ensuring appropriate care for older patients.

On the other hand, our research results confirm that there is no 'one size fits all' solution. Healthcare clinicians and managers need to select carefully the type of GGHIT that will be the most appropriate based on the needs of their organizations and clienteles.[138] The acquisition of dependable hardware and software appears an absolute necessity. Equally important, the choice of technology should also take into account its compatibility with the overall organizational system.[2 35 139] Indeed, extant research shows that compatibility is often negatively evaluated by HIT users,[90 92 93] in particular due to a loss of human contact and privacy issues[90] or because of a perception of decreased clinical autonomy.[94 100] In addition, among the most important challenges faced in age-related care is the issue of simplicity, which includes the development of systems that are truly user friendly and user oriented.[140] If GGHIT are difficult to use, for example, when there are too many reminders or when the information content is complex,[94] it may become a barrier to adoption and use.

Our results also indicate that to maximize the implementation success of GGHIT, it is essential to identify the best methods of integrating the use of HIT into clinicians' routine workflow. Our study highlights the role of observability and trialability in the implementation dynamic. In this perspective, repetitive testing seems to improve initial system use.[141] The education and training of users are also crucial.[140] More specifically, results suggest that it is important to ensure timely user support, to document system problems and provide prompt feedback.[142]

Our review has some limitations. As explained in the critical appraisal section, the quality of the studies included varies considerably. Nevertheless, a sensitivity analysis did not reveal that inclusion of poor quality studies was skewing the results. Our review may also suffer from publication bias as studies reporting positive outcomes are more frequently published than studies with negative outcomes.[18]

## CONCLUSION

The typology we propose in this paper can contribute to more informed system selection decisions by healthcare managers and caregivers. The findings of this study can be used by organizations to guide the specific implementation strategies that provide the best chances of success for each type of GGHIT. As it identifies the nature of different GGHIT, as well as many of the benefits and challenges associated with their use, it could be used by organizations to tailor their policies regarding the choice, planning, diffusion, and monitoring of HIT implemented for the care of older adults. Finally, given that the majority of the studies conducted to date deal with telecare technologies, an avenue for future research would be to focus on other types of GGHIT such as EHR, DSS, web packages, etc.

**Correction notice** This article has been corrected since it was published Online First. The second author has added an additional affiliation.

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