Interactive Voice Response Systems for Improving Delivery of Ambulatory Care

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Objective: To comprehensively describe the populations, interventions, and outcomes of interactive voice response system (IVRS) clinical trials.

Methods: We identified studies using MEDLINE (1950-2008) and EMBASE (1980-2008). We also identified studies using hand searches of the Science Citation Index and the reference lists of included articles. Included were randomized and controlled clinical trials that examined the effect of an IVRS intervention on clinical end points, measures of disease control, process adherence, or quality-of-life measures. Continuous and dichotomous outcomes were meta-analyzed using mean difference and median effects methodology, respectively.

Results: Forty studies (n = 106,959 patients) met inclusion criteria. Of these studies, 25 used an IVRS intervention aimed at encouraging adherence with recommended tests, treatments, or behaviors; the remaining 15 used an IVRS for chronic disease management. Three studies reported clinical end points, which could not be statistically pooled. In 6 studies that reported objective clinical measures of disease control (glycosylated hemoglobin, total cholesterol, and serum glucose), the IVRS was associated with nonsignificant improvements. In 14 studies that measured objective process adherence outcomes, the median effect was 7.9% (25th-75th percentile: 2.8%, 19.5%). For the 16 studies that assessed patient-reported measures of disease control and the 11 studies that assessed patient-reported process adherence outcomes, approximately one-third of the outcomes significantly favored the IVRS group.

Conclusion: IVRS interventions, which enable patients to interact with computer databases via telephone, have shown a significant benefit in adherence to various processes of care. Future IVRS studies should include clinically relevant outcomes.

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For high-quality ambulatory care, physicians and their healthcare team must have a high level of communication with patients between visits. These interactions frequently include the provision of treatment advice and monitoring of chronic disease.[1-3] Physicians must support patients and advise them to achieve adherence with test, treatment, and behavioral recommendations. Patients who receive a timely reminder are significantly more likely to have screening tests.[4-6] Similarly, the management of chronic diseases often requires ongoing assessments of various clinical parameters between visits (eg, glucose values in patients with diabetes or body weight in patients with heart failure).[7-10] Patients may experience improved outcomes if their treatment is promptly modified after measurements outside of the desired treatment ranges. The capacity for physicians to fulfill such monitoring and support functions is greatly limited by various factors, including a reimbursement system that does not explicitly recognize the time required to perform them.[2,3]

Information and communication technologies may effectively and efficiently facilitate intervisit management.[1,11,12] One such technology, the interactive voice response system (IVRS), could be used to contact patients with reminders or to track patient-assessed parameters measured at home. The IVRS is a technology that enables patients to interact with computer databases via telephones.[13,14] It prompts patients to provide information following a scripted dialogue. It captures responses using keypad entry or speech recognition and stores the information in a database. Patient responses may trigger the IVRS to perform other actions such as sending electronic notifications. Other information and communication technologies, such as patient-accessible Web portals and e-mail, also could be used to support intervisit management. However, IVRS may be more easily adopted because most people own and can use a telephone.

A comprehensive analysis of the utility of IVRS-based interventions is needed. Although used in industries other than healthcare for years, IVRSs only recently were adopted for use in healthcare settings.[13] As a result, their effectiveness in improving care and acceptability to patients is largely unknown. Although some data suggest they are effective, negative studies also exist. Furthermore, very few published studies of IVRS interventions have used a comprehensive health technology assessment framework that evaluates

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Take-Away Points

A systematic review was performed to comprehensively describe the populations, interventions, and outcomes of interactive voice response system (IVRS) clinical trials.

- IVRS-based interventions are feasible in many settings and can result in modest improvements in adherence to many processes of care.
- We caution against the interpretation that IVRS improves outcomes, as there are currently insufficient data to support such a conclusion.

processes and outcomes of care. A systematic review of IVRS interventions will identify gaps in the current evidence, investigate the utility of this technology, and inform future technology development. Although prior reviews of IVRS technologies were conducted in 2002 and 2003,[15,16] these studies did not quantitatively examine the effects of IVRS on outcomes. Also, more than 10 IVRS randomized controlled trials (RCTs) have been published since 2003. For these reasons, we conducted a systematic review to comprehensively describe the populations, interventions, and outcomes of IVRS clinical trials.

METHODS

Data Sources

We identified potentially pertinent citations in the MEDLINE database (1950-2008) using the search strategy in eAppendix A (available at **www.ajmc.com**). We used a combination of key words related to IVRS (eg, automated, telephone). We modified the MEDLINE search to identify citations in the EMBASE database (1980-2008). We also included studies found using hand searches of the Science Citation Index and the reference lists of included articles.

Study Selection

We retrieved the full text of articles if the title or abstract suggested that the investigators evaluated an IVRS. We included studies published in English that examined the effect of an IVRS intervention on at least 1 of the following types of outcomes: clinical end points, measures of disease control, process adherence, and quality-of-life measures. *Clinical end points* included disease-related outcomes such as death or hospitalization; *measures of disease control* were objective and patient-reported markers of disease or health status such as blood pressure, glycosylated hemoglobin (A1C), or a score on a disease-specific validated scale; *process adherence* outcomes assessed whether patients followed a targeted process of care such as screening tests, immunization protocols, or home glucose monitoring; and *quality-of-life* measures included general health scores from validated questionnaires. Only RCTs and controlled clinical trials (CCTs) (ie, trials that included at least 2 groups and used a quasi-random allocation method) were included in the review. Studies that used an IVRS only to collect data or conducted a validation study were excluded.

Data Abstraction

From each study, we abstracted details about the population, the IVRS intervention, and outcomes according to an intention-to-treat approach. If a study presented data for more than 2 groups, we abstracted data for 1 intervention group and 1 control group to capture the most direct comparison (eAppendix B available at **www.ajmc.com**). Where possible, we included the intervention group that received the IVRS intervention only and the control group that received no intervention. If no such groups were reported, we included the intervention group that received the IVRS intervention plus the simplest other intervention (eg, educational booklet) and the control group that received the same simple intervention. Two reviewers (NO and AJ) independently abstracted the data.

Study Quality Assessment

We assigned studies an overall quality score using the checklist specified by the Cochrane Effective Practice and Organization of Care group.[17] The checklist, used for both RCTs and CCTs, included 3 primary criteria (concealment of allocation, blind assessment of primary outcome, completeness of follow-up) and 3 secondary criteria (balanced baseline measures, reliable outcome measures, protection against contamination). Studies were classified as high quality when they satisfied all primary criteria and did not elicit significant concerns regarding the secondary criteria, as moderate quality if 1 or 2 of the primary criteria were scored as "not clear" or "not done," and as low quality if the 3 primary criteria were scored as not clear or not done.[18]

Analysis

Meta-analyses within the various outcome categories were limited because of heterogeneity across the outcomes. In addition, a significant number of studies captured patient-reported outcomes that were not externally validated (eg, patient-reported exercise frequency). To minimize bias, outcomes that were not externally validated were not included in our quantitative analyses. Among the studies that measured outcomes that could not be externally validated (eg, pain), heterogeneity across the outcomes prevented meta-analyses. Study data could be pooled only for measures of disease control that were clinical and dichotomous process adherence outcomes.

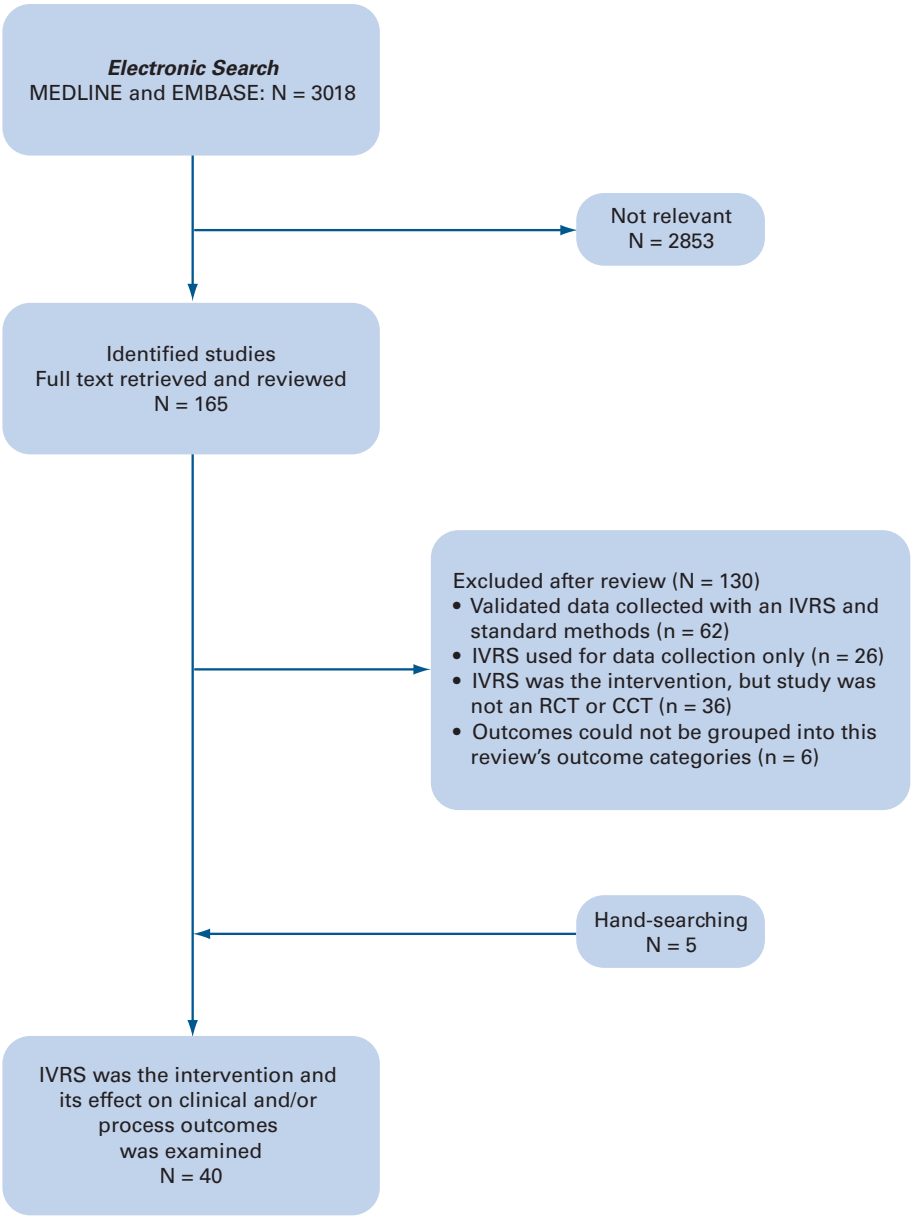
For the different types of measures of disease control, we calculated the overall mean difference. These calculations required the mean and standard deviation for intervention and

control groups. If a study did not report standard deviations, we used reported statistics (eg, *P* value) to impute a standard deviation for both study groups.[19] Analyses were performed using Review Manager version 4.2.10 (The Cochrane Collaboration, The Nordic Cochrane Centre, Copenhagen, Denmark).

For dichotomous process adherence outcomes, we calculated the overall effect estimate using median effects methodology.[20] We first calculated the median effect, defined as the absolute percentage change between the intervention and control groups, for each study. If a study presented more than 1 dichotomous process adherence outcome, we ranked the study's effect sizes and selected the median. Individual study effects then were ranked, and the median and interquartile range were selected as the summary process adherence measure. These analyses were performed using SAS version 9.1 (SAS Institute Inc, Cary, NC).

Change scores were calculated for objective outcomes that could not be pooled and patient-reported outcomes. The change score was defined as the difference between the change from baseline to follow-up in the intervention and control groups. If a study did not report baseline measures, the change score was the difference between follow-up measures for the 2 groups. No analyses were performed on these data.

Figure 1. Study Flow



CCT indicates controlled clinical trial; IVRS, interactive voice response system; RCT, randomized controlled trial.

RESULTS

Study Identification and Description

Our electronic search yielded 3018 citations (**Figure 1**). The full text of 165 citations was retrieved and reviewed. We excluded studies where the IVRS was not the study intervention (n = 88), the study design was not an RCT or CCT (n = 36), and the study outcomes could not be grouped into this study's outcome categories (n = 6). An additional 5 included studies were retrieved by hand-searching.

Forty studies published between 1989 and 2008 met inclusion criteria (**eAppendix C** available at **www.ajmc.com**). Thirty-two studies were RCTs[21-53] and 8 were CCTs.[54-61] Nearly two-thirds of the studies were conducted at a community practice (n = 26). The remaining studies were conducted at specialty clinics (n = 7), health management organizations (n = 4), home care companies (n = 2), and a Veterans Affairs medical center (n = 1). The 40 studies included a total

Table. Effect of IVRS on Clinical End Points[a]

Study	Year	Outcome	Intervention (I) No.	Intervention (I) Baseline	Intervention (I) Follow-Up	Intervention (I) Change	Control (C) No.	Control (C) Baseline	Control (C) Follow-Up	Control (C) Change	Total Change (I – C)	Difference[b]
Asthma												
Vollmer[40]	2006	Acute asthma care visit	3220		10.9		3033		10.0		0.9	NS
Vollmer[40]	2006	Emergency department visit or hospitalization	3220		4.1		3033		4.0		0.1	NS
Vollmer[40]	2006	Required routine visit for asthma	3220		49.3		3033		47.4		1.9	NS
Heart failure												
Capomolla[47]	2004	Cardiac death	67		6.0		66		11.0		11.0	−5.0
Capomolla[47]	2004	At least 1 event (hospitalization, cardiac transplantation, death, emergency department visit)	67		24.0		66		45.0		−21.0	+
Heidenreich[60]	1999	Admissions per year (mean ± SD)	68	2.4 ± 3.3	1.9 ± 3.8	−0.5	86	1.8 ± 3.3	3.4 ± 6.7	1.6	−2.1	NS
Heidenreich[60]	1999	Hospital days per year (mean ± SD)	68	8.6 ± 19.0	4.8 ± 10.0	−3.8	86	8.9 ± 21	17 ± 38	8.1	−11.9	+

C indicates control; I, intervention; IVRS, interactive voice response system; NS, not significant.
[a]Results are presented as percentage of patients unless otherwise indicated.
[b]Plus sign (+) significantly favors the intervention group.

of 106,959 patients. The median sample size was 237 (25th-75th percentile: 122-647). Participant follow-up varied from 1 month to 1 year. The mean age and sex distribution of each study are detailed in eAppendix C.

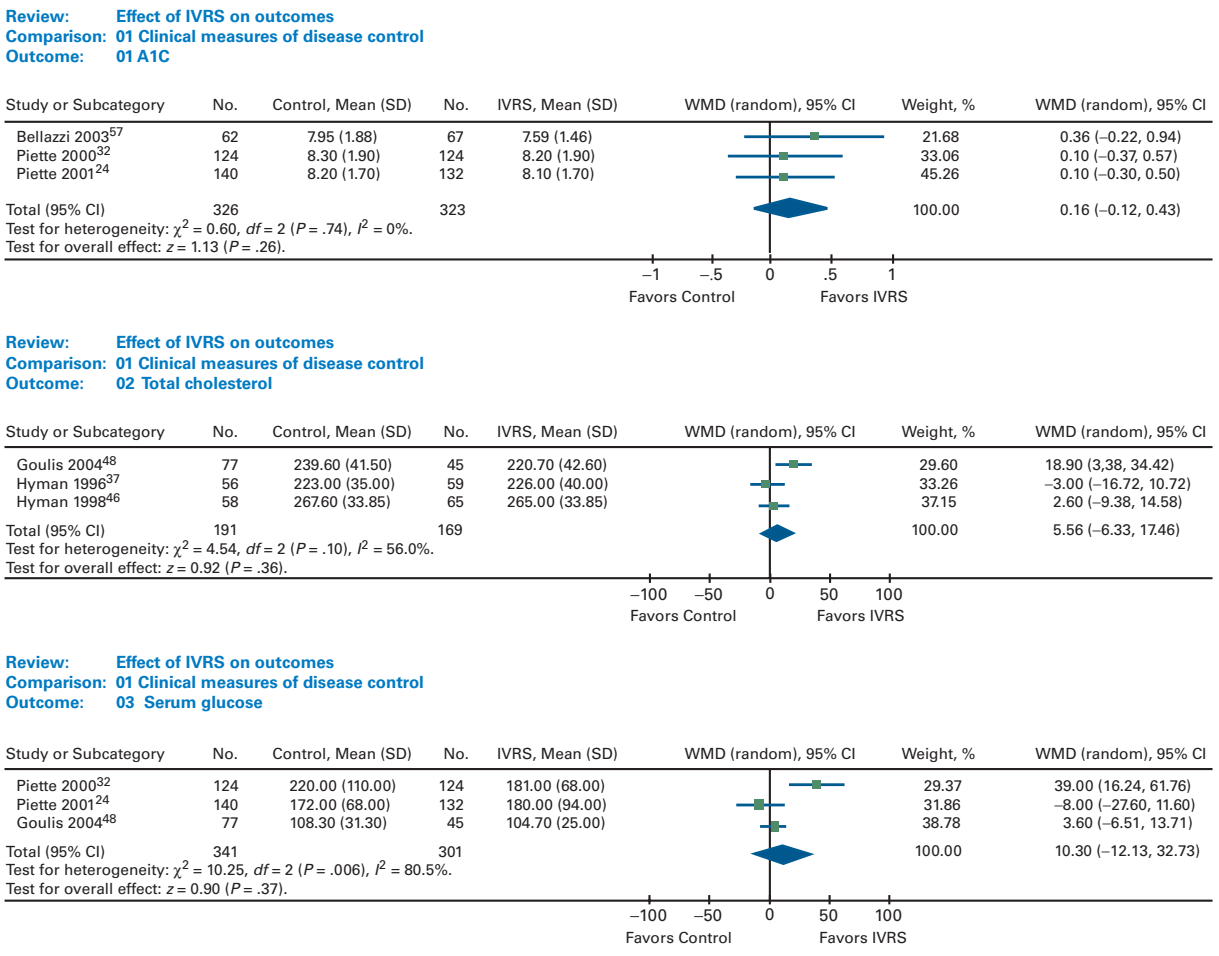
The majority of studies (n = 25) used an IVRS for achieving adherence with treatments, screening, tests, or recommended behavior modifications (eAppendix C).[21,23,26,28-31,33-35,38,39,41-44,48-50,52,54-56,58,59] The most common targeted behaviors were immunization (n = 10) and healthy lifestyle (n = 5). Of the 24 studies, 12 used an IVRS to deliver reminders (eg, immunization, laboratory monitoring). These IVRSs were programmed to contact patients between 1 and 7 days before the appointment. The remaining IVRSs were used to assess and reinforce behaviors. Patients in these studies were instructed to call the toll-free IVRS at an interval that ranged from daily to weekly. In 4 of the 25 studies, the IVRS was a part of a multifaceted intervention.[44,48,50,52] By far the most common outcome among these studies was process adherence. None of the 25 studies measured clinical end points, and 6 examined a measure of disease control.

Fifteen studies[22,24,25,27,32,36,37,40,45-47,51,57,60,61] used an IVRS for managing chronic disease (eAppendix C), most commonly diabetes (n = 3), heart failure (n = 3), and mental illness (n = 3). Of the 15 studies, 12 used an IVRS to collect clinical measurements (eg, blood pressure) or assess disease symptoms (eg, hypoglycemia for diabetes patients). Frequently, patients' report of symptoms triggered follow-up from a healthcare professional. The other 3 studies used an IVRS that administered treatment modules or assessed patients' needs for therapy changes. The majority of the 15 IVRSs were programmed to provide personalized feedback to participants based on their responses during the automated dialogue. In 6 of the 15 studies, the IVRS was a part of a multifaceted intervention.[27,46,47,51,57,60] The most common outcomes among the chronic disease studies were measures of disease control and process adherence.

Study Quality Assessment

Seven studies were considered to be high quality,[24,26,29,32,37,41,46] 27 studies were considered to be moderate quality,[21-23,25,27,28,30,31,33-36,40,43,45,47-52,55-60] and 6 studies were considered to be low quality.[38,39,42,44,54,61] Randomization was clearly done in 11 studies[21,24,26,28,29,32,37,41,46,48,52] and not done in 7 studies.[54-56,58-61] It was not clear whether randomization had been done in 22 studies.[22,23,25,27,30,31,33-36,38-40,42-45,47,49-51,57] Twenty-nine studies reported more than 80% follow-up,[21-27,29-33,35-37,40,41,43,45-52,58-60] and 4 reported less than 80% follow-up.[38,39,42,61] The follow-up rate was not reported in 7 studies.[28,34,44,54-57] With respect to the third important quality criterion, 22 studies blindly assessed their primary outcome,[23-26,28-34,36,37,41,43,46,47,55-58,60] and 16 did

Figure 2. Meta-Analyses of Studies Evaluating Clinical Measures of Disease Control



A1C indicates glycosylated hemoglobin; CI, confidence interval; IVRS, interactive voice response system; WMD, weighted mean difference.

not.[21,22,27,35,38-40,42,44,48-52,59,61] It was not clear whether blind assessment of the primary outcome was done in 2 studies.[45,54] We assessed study quality to further describe the included studies. Study quality was not used to conduct sensitivity analyses because the meta-analyses were already limited by study heterogeneity.

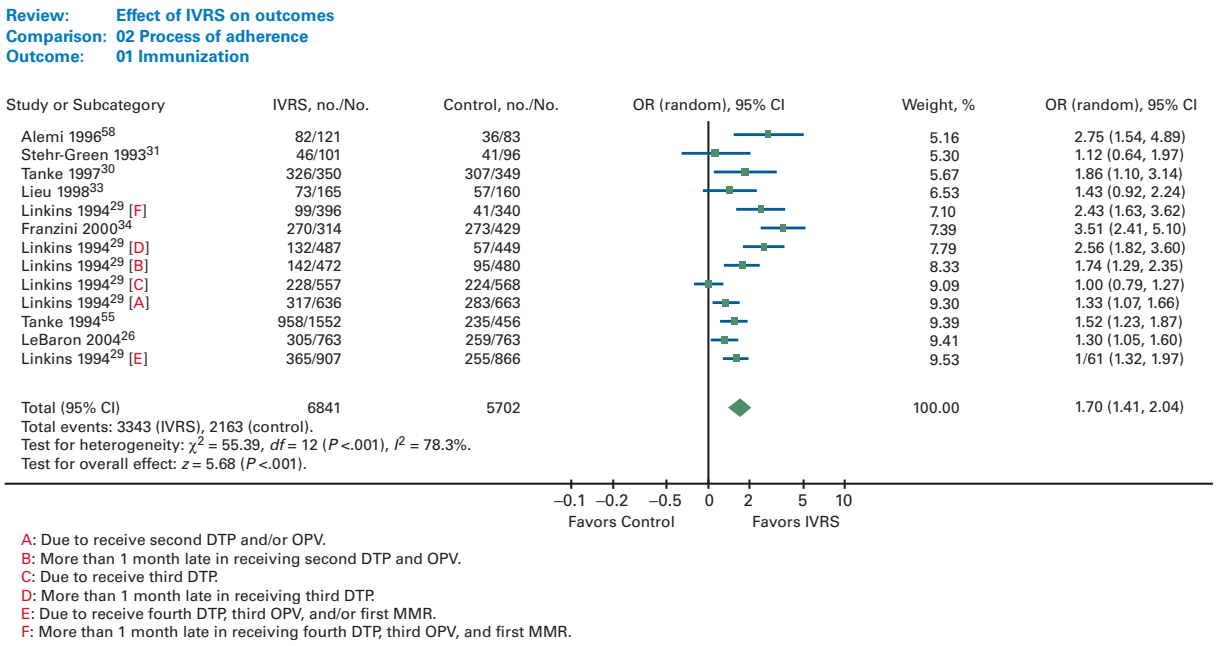
Effect of IVRS Interventions on Outcomes

Only 3 studies reported clinical end points (Table). We could not pool these data because the specific outcomes varied across the studies. For the 2 studies of heart failure patients, the IVRS was associated with improved outcomes. However, the sample sizes of the 2 studies were very small (n = 70). No difference was found between the intervention and control groups in the asthma study.

Six studies reported externally validated measures of disease status that were clinical. The specific outcomes evaluated in these studies varied (Figure 2). The outcomes included A1C, total cholesterol, and serum glucose. Overall, the IVRS interventions were associated with a nonsignificant improvement in all outcomes. The pooled mean differences (95% confidence interval [CI]) were 0.16 (–0.12, 0.43) for A1C, 5.56 (–6.33, 17.46) for total cholesterol, and 10.30 (–12.13, 32.73) for serum glucose. It is noteworthy that none of the sample sizes were larger than 140 patients.

Across all studies, the most common outcome was process adherence. Fifteen studies measured 24 objective, dichotomous process adherence outcomes. However, 1 study was excluded from the analysis because it reported only the relative change in screening rates between the intervention and control groups.[43] For the 14 other studies, the median effect of the IVRS intervention was significant at 7.9% (interquartile range 2.8-19.5). As a subgroup analysis, we pooled 8 studies that measured immunization rates. Overall, patients who received the IVRS intervention had significantly higher immunization rates (odds ratio = 1.70; 95% CI = 1.41, 2.04).

Figure 3. Forest Plot of Immunization (Patient Process Adherence Outcome)



A: Due to receive second DTP and/or OPV.
B: More than 1 month late in receiving second DTP and OPV.
C: Due to receive third DTP.
D: More than 1 month late in receiving third DTP.
E: Due to receive fourth DTP, third OPV, and/or first MMR.
F: More than 1 month late in receiving fourth DTP, third OPV, and first MMR.

CI indicates confidence interval; DPT, diphtheria, pertussis, and tetanus; IVRS, interactive voice response system; MMR, measles, mumps, and rubella; OPV, oral polio vaccine; OR, odds ratio.

We also performed a sensitivity analysis to examine whether the median effect differed by process type (immunization vs other) and found no such effect (**Figure 3**).

Twenty-four studies reported a total of 74 patient-reported outcomes. Sixty percent of the outcomes were measures of disease control, which ranged from weight to scores on the obsessive-compulsive disorder scale. The remaining 40% of outcomes assessed patient process adherence. These outcomes ranged from medication adherence to physical activity. Because of the heterogeneity across all patient-reported outcomes and the susceptibility to bias of many of the outcomes, we did not analyze these outcomes. However, we did abstract study information for descriptive purposes (**eAppendix D** available at **www.ajmc.com**). For two-thirds of the outcomes, there were no significant differences between the intervention and control groups. The other outcomes had results that favored the IVRS intervention.

We summarize quality-of-life outcomes in **eAppendix E** (available at **www.ajmc.com**). Five studies used 4 different scales to measure general health outcomes. Two studies used the 36-Item Short Form Health Survey (SF-36), 2 used the Work and Social Adjustment Scale, and the other used the General Health Status Index. Because of these differences, we did not combine the data. Of the 5 studies, 2 reported that the IVRS intervention was associated with significant improvements in general health.

DISCUSSION

Our study highlights the potential usefulness of IVRS for facilitating 2 aspects of ambulatory care: ensuring adherence with tests, treatments, and behavior change; and managing chronic disease. We identified 40 clinical trials evaluating different IVRS-based interventions, which were implemented in diverse settings for a number of medical conditions. Not surprisingly, the diversity of the studies created difficulty in making definitive conclusions about the technology's overall effectiveness. However, the available data suggest a modest beneficial effect. We found IVRS-based interventions were associated with a 7.9% improvement in adherence with recommended treatments and tests. In addition, IVRS-based interventions were associated with a trend toward improvement in clinical measures associated with better disease outcomes in patients with diabetes, hypertension, and dyslipidemia. The impact of IVRS-based interventions on clinical end points is largely unstudied, but 1 of the 3 studies that did measure clinical end points found a reduction in hospital days for patients with heart failure.

In an era of greater accountability for physicians and health systems, any tool that can improve adherence with recommended therapies and treatments may be worthy of implementation, even in the absence of proof of an effect on outcomes. Many health plans, including Medicare, are

implementing initiatives to monitor the performance of their providers.[62,63] Some of these initiatives include pay for performance, in which providers receive financial rewards for meeting explicit standards of care or indicators. Commonly, these indicators are defined using evidence-based processes of care and surrogate outcomes. Examples of such indicators include adherence to screening guidelines in selected populations and the proportion of patients meeting lipid or hypertension targets. Rarely, if ever, do plans use patient outcomes as a measure of performance. As demonstrated in this review, IVRS can be leveraged to obtain better performance on such process indicators.

Interactive voice response systems may be used alone or as a complement to other initiatives or technologies. For example, IVRSs can be linked with components of the electronic health record, thereby expanding this promising technology's benefit. In fact, it may be easier to implement and monitor the impact of an IVRS that is integrated with an existing information system infrastructure. Also, recent quality improvement studies have focused on different organizational approaches for chronic disease management. A common component of many of these initiatives is frequent telephone contact.[64-68] Such calls usually involve the patient providing data on his or her health status and the practitioner providing advice. For many diseases and situations, this information can be standardized, which in turn lends itself to the use of an automated IVRS solution. It should be noted that in this approach the IVRS would be designed to improve the efficiency of the nurses and other personnel in the program, not to replace them. Thus, the IVRS will help screen patients who might be having problems, so the nurse or physician responsible for the program can focus on them, rather than spend a disproportionate amount of time on patients who are well.

The current study provides the most thorough and up-to-date evaluation of the use of IVRS technology in healthcare. Our review has a number of strengths. We identified and included studies using widely accepted criteria of methodologic rigor. We classified interventions and outcomes using a predefined framework that provides a more comprehensive assessment. In some cases, this allowed us to pool individual study results to determine an overall effect. These effects are less biased because we excluded studies with patient-reported outcomes.

There also are some limitations to this review. Many different study outcomes were evaluated, and few studies evaluated the technology using both clinical and process outcomes. It is noteworthy that only 3 of the 39 studies measured clinical end points. Another predominant issue in the included studies was the common use of patient-reported outcomes. Although patient input is clearly important, it is arguably more important to use externally validated objective outcomes when performing technology assessments. Finally, although we did perform a rigorous search to identify published literature, it is possible that some studies of IVRSs are not published.

We conclude that IVRS-based interventions are feasible in many settings and can result in modest improvements in adherence to many processes of care. If provider groups are focused on improving specific processes of care, then we feel the published data support a decision to implement the technology. However, we must caution against an interpretation that the technology improves outcomes, as there are currently insufficient data to support such a conclusion. We recommend that future studies evaluate patient outcomes in addition to focusing on process measures.

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