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*Original Article*

# Outcomes of a Prospective Surveillance and a Local Consensus-based Guideline to Promote the Intravenous-oral Conversion of Antibiotics

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**Abstract** An intravenous-to-oral antibiotic conversion can lower drug costs, reduce patient's hospital stay, and improve patient's comfort, without sacrificing effectiveness of the treatment. In Thailand, the IV-oral conversion has not received much attention from administrators as an effective cost containment strategy nor has been widely implemented. To examine the effects of an IV-oral conversion of antibiotics using two distinct approaches: the prospective surveillance and the local consensus-based guideline. A pre-post study design was used, and effects of each strategy were examined twice (*i.e.,* the immediate effects and the effects at month four). Measures of the effectiveness included incidence of converted prescriptions when they met the conversion criteria, excess IV days of target drugs, and potentially avoidable cost (PAC). The prospective surveillance increased the conversion incidence by 14%, reduced the excess IV days by 72% and PAC by 71% for the immediate assessment, and had no effects at month four. The local consensus-based guideline increased the conversion incidence by 7% as the immediate effect, and reduced the excess days by 44% and 52% as the immediate and four-month effects, respectively. This was accompanied by a reduction in the PAC by 55% for the four-month assessment. Both prospective surveillance and local consensus-based guideline strategies to promote IV-oral conversion of antibiotics for hospitalized patients provided positive economic impacts. The local consensus-based guideline yielded greater long-term benefits. The prospective surveillance yielded a greater effect but for a shorter period, thus should be implemented on a continual basis. 

**Keywords**: clinical pharmacist, guideline, interventions, IV-oral conversion

## INTRODUCTION

A conversion to the bioequivalent oral form of an intravenous (IV) medication has been established as an effective strategy in reducing medical cost and patient's hospital stay as well as improving patient's comfort.[1-5] Criteria for IV-oral conversion are explicit and have been widely implemented for antibiotics.[1-2] In Thailand, approximately 24% of total drug expenditures were accounted by the IV medication used in hospitalized patients of which about one-third was shared by antibiotics.[6] Though the Thai health care sectors have been facing a two-digit increase in the recurrent expenditures,[7] the IV-oral conversion has yet received much attention from administrators as an effective cost containment strategy and has not been widely accepted in routine clinical practice.

The surveillance approach conducted by pharmacists, which consists of a review IV medication orders, provide feedback, and give reminders to the physicians to switch their IV orders to oral medications requires a continuum of case-based interventions, hence

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relatively time consumes.[8-9] As such, it might not be suitable for most hospitals in Thailand that tend to have the problem of staff shortage. An internal motivation approach using educational meeting to build local consensus among the prescribers and to develop the evidence-based IV-oral conversion guideline may be a more viable option.

The present study examines the effects of IV-oral conversion with the distinct, the pharmacist-initiated prospective surveillance (surveillance approach) and the hospital-wide, local consensus-based guideline (guideline approach). Both immediate and long-term effects on a decrease in unnecessary use of the IV forms of target antibiotics were assessed to guide whether the interventions should be given on a continual basis.

## MATERIALS AND METHODS

### *IV-Oral Conversion Criteria*

The first step in developing the IV-oral conversion criteria was a review of the relevant literature via PubMed and Medline, using the keywords: switch therapy, sequential therapy, IV-oral conversion, criteria, guideline, and antimicrobials. The second step included an interview of twelve senior specialists for their opinions on practical IV-oral conversion. The criteria were evaluated for content validity by the specialists in internal medicine and infectious diseases. The criteria used in the surveillance approach contained 20 antibiotics, whereas those in the guideline approach contained 11 antibiotics (more details about the guideline are presented in Appendix).

The targeted IV drugs were divided into two categories, sequential and switch therapy. Sequential therapy refers to conversions of the use of the same drug for IV and oral administration, if it has excellent bio-availability and the switch of the same drug with the reduction in achievable systemic drug concentration. Specifically, the term switch therapy involves (1) the IV antibiotics that lack an oral counterpart, an oral agent from different class with similar spectrum of activity and good absorption is indicated, and (2) the switching to a same or a different drug with relatively limited absorption.

For the sequential therapy, medication can be converted to an oral form as soon as possible, once the patients can take medications orally. For switch therapy, medication can be converted to oral drugs only after the patients achieve clinical improvement. Exclusion criteria were as follows. Patients were diagnosed to have bacterial meningitis, bacterial endocarditis, endophthamitis, and febrile neutropenia where IV therapy was needed for the whole course of therapy. Patients with melioidosis, leptospirosis, spontaneous bacterial peritonitis, crypto-coccal meningitis, or surgical prophylaxis were required for specific duration of IV therapy. Patient were diagnosed to have bone and joint infection (*e.g.*, septic arthritis, osteomyelitis) or liver abscess where prolong of IV therapy was required more than two weeks or patients were diagnosed to have serious or life-threatening infection where IV therapy was needed until the whole courses of therapy.

### *Study Design*

A pre-post design was used to determine the effect of the surveillance approach and the guideline approach to promote IV-oral conversion. The study was conducted at a tertiary medical center of 800 beds, located in the northern region of Thailand. The study was approved by the ethical review committee of the Ministry of Public Health and the study hospital. The study was divided into two parts. The first part examined the effectiveness of the surveillance and the second part did so for the guideline approach. After the testing of the surveillance was complete, the guideline approach was initiated and then tested. Baseline data were collected before the initiation of the surveillance approach (phase I). The immediate effects of the surveillance approach were measured concurrently (phase II) while the inter-ventions were being implemented. Four months after the initiation of the surveillance approach, data were collected for the four-month effects (phase III). It was pre-determined that if a four-month assessment of the surveillance approach revealed similar

effects on all study endpoints as its baseline, the data would also serve as the baseline for the guideline approach. If the effects were different, additional observation at the extended period would be obtained until the data returned to the same levels as the surveillance approach's baseline or the guideline approach was to be conducted in other settings. Once the guideline approach was completely implemented, data for the immediate effects were collected (phase IV). Finally, four months later, data were collected for the four-month effects (phase V).

*Prospective Surveillance Approach*

The prospective surveillance approach was conducted by a clinical pharmacist who reviewed medical charts to detect the non-switched prescriptions when the criteria were met. The index date was the time that the targeted IV antibiotics could be converted to the oral form according to the set criteria. Once the candidates and their index dates were detected, the pharmacist would directly inform the attending physician regarding the IV-oral conversion information specific to the patient. If the physician was not present at the intervention time, the pharmacist would provide written reminders specific to the candidates. The long term effect was measured four months later to determine whether the surveillance approach had a remaining effect.

*Local Consensus-based Guideline Approach*

After the surveillance approach was completely tested, physicians' opinions were sought on the former IV-oral conversion criteria, using a questionnaire for the ways to improve the guideline to be more practical in daily practice. An interactive educational meeting was conducted on the basis of adult learning theories that professionals can be intrinsically motivated by education.[10] The educational meeting was led by an expert in infectious diseases and IV-oral conversion. During the meeting, the consensus of the IV-oral conversion guideline was made, and its benefits and potential barriers to application were discussed. The participating physicians (n = 40) brought up several interesting cases on when to convert the IV to oral forms. The guideline approach contained only 11 target medications, with the same criteria used in the surveillance approach. The developed guideline was then approved to be the official Hospital Guideline. The hospital IV-oral conversion guideline was regularly reiterated during the meetings of the departments, and physician organizations.

*Study Patients*

The target population was the patients aged over one year who were prescribed the targeted IV medications, and were hospitalized for at least 24 hours. The pattern of the IV-oral conversion in real medical practice was the study focus, and thus the study included patients regardless of specific disease conditions. Prescriptions for the IV targets, which were prescribed for less than or equal to 72 hours, changed to another IV therapy, or discontinued before meeting the conversion criteria were not included, in order to select only the true candidates for IV-oral conversion. The study patients were not diagnosed with the diseases that the IV-oral conversion could not be applied, as indicated in the criteria above.

*Study Outcomes and Data Collection*

Measures of the effectiveness of each promoting approach included (1) incidence of the converted prescriptions when they met the criteria; (2) excess IV days, and (3) potentially avoidable cost (PAC). The incidence was measured in terms of the number of targeted drug prescriptions, which were converted from IV to oral forms before or at the index date, divided by the number of all prescriptions eligible for the IV-oral conversion. The excess days were counted from the index date to the date when physicians stopped the IV targeted medication. The PAC was a difference between cost of the IV form and cost of the oral form of the targeted medication during the excess days. The IV cost included drug acquisition cost, and the material and labor costs associated with administration.

For each phase, patient medical charts were reviewed prospectively each day so as to identify the eligible prescriptions and the

prescriptions converted according to the set criteria. Data collection was performed by a clinical pharmacist who was trained intensively on the good practice of IV-oral conversion. The degree of agreement between the data collector and the expert was high (97.8%, kappa = 0.93). Research questions and hypotheses were not made known to health care providers in the study hospital to minimize the potential of Hawthorne effect.

*Data Analysis*

The primary unit of analysis for the three study outcomes was at the prescription level since each patient might have more than one targeted medication prescribed. The analyses were based on the eleven IV antibiotics which were the targets of both promoting approaches.

For each period, data were collected for a two-week duration in order to ensure that the number of prescriptions studied was adequate. The estimated incidence of converted prescriptions when the criteria would have been justified, before the intervention was 46% and that after the intervention was 62%.[2,11-13] The required sample size was 202 prescriptions for each period, with a power of 90% and type I error at 0.05.

It was predetermined that the immediate effect and the long-term effect of each promoting approach would be compared with the baseline. In addition, the immediate and long-term effects between the two approaches were compared. A comparison of incidences of the converted prescriptions was made using an independent *t*-test. For the excess days and PAC, generalized linear models using gamma distribution with log-link function were used to compare pre- and post-interventions. The intervention effects, clustered by prescribing physicians, were controlled for patient demographics, Charlson Index capturing patient co-morbidity, history of admission to intensive care unit (ICU), drug classes, and patient wards.

## RESULTS

Table 1 lists the demographics of all eligible patients. A majority of the patients were admitted to surgical wards, medical wards, and orthopedic wards. Approximately one-quarter of the patients had co-morbidities as indicated by the Charlson Index. The patients who had ICU admission accounted for approximately 8%. The average length of stay (LOS) for different phases ranged from 10 to 14 days. A majority of the patients were discharged with clinical improvement. No statistically significant differences in the patient characteristics were apparent across the five phases except for the admission department ($p = 0.020$), LOS ($p < 0.001$) and discharge status ($p = 0.012$). An increase in the combined rate of death or no improvement after implementation of the guideline approach was not due to IV-oral conversion.

The outcomes of the two promoting approaches are presented in Table 2. For the surveillance approach, considered at the index date, the incidences of switched prescriptions for sequential and switching therapy categories were 22% and 72% at baseline, 57% and 83% for the immediate effect, and 28% and 69% for the long term effect, respectively. The incidences as the immediate effect were significantly higher for both sequential ($p < 0.001$) and switching therapies ($p = 0.003$), whereas the incidences of converted prescriptions at the fourth month returned to baseline level.

For the guideline approach, the incidences of converted prescriptions evaluated at the index date for sequential and switching therapy categories were 49% and 77% for immediate effect, and 21% and 80% for long term effect, respectively. For the immediate effect, the guideline approach significantly increased the incidences of converted prescriptions overall by 7% ($p = 0.038$). The immediate effects of the guideline approach on incidences of converted prescriptions were significantly higher for both sequential ($p = 0.027$) and switching therapy categories ($p = 0.022$), whereas at the fourth month the long term

effect was found significantly higher only for the switching therapy category ($p = 0.004$).

Considering the incidences of converted prescriptions when the criteria were met, the immediate effect of the surveillance approach was stronger than that of the guideline approach. In contrary, the guideline approach significantly increased in the incidence of converted prescriptions in the switching therapy category by 10% ($p = 0.004$), as compared

**Table 1.** Characteristics of study patients and the antibiotics prescribed

| Variables | Phase I n = 272 | Phase II n = 206 | Phase III n = 283 | Phase IV n = 259 | Phase V n = 225 |
|---|---|---|---|---|---|
| Total eligible prescriptions | 377 | 281 | 354 | 357 | 304 |
| Numbers of prescriptions of target IV medications per patient: n (%) | 177 (65.1) | 134 (65.0) | 221 (78.1) | 174 (67.2) | 155 (68.9) |
| 1 | 85 (31.2) | 67 (32.5) | 51 (18.0) | 72 (27.8) | 64 (28.4) |
| 2 | 10 (3.7) | 5 (2.4) | 11 (3.9) | 13 (5.0) | 5 (2.2) |
| 3 | 0 | 0 | 0 | 0 | 1 (0.4) |
| 6 | | | | | |
| Male: n (%) | 151 (55.5) | 134 (65.0) | 169 (59.7) | 146 (56.4) | 136 (60.4) |
| Age: mean ± S.D. (years) | 46.8 ± 20.7 | 45.0 ± 21.7 | 45.1 ± 23.1 | 47.9 ± 20.1 | 46.2 ± 22.5 |
| Department: n (%) | | | | | |
| Medical ward | 74 (27.2) | 37 (18.0) | 58 (20.5) | 49 (18.9) | 44 (19.6) |
| Surgical ward | 132 (48.5) | 120 (58.2) | 128 (45.2) | 132 (51.0) | 115 (51.1) |
| Orthopedic ward | 28 (10.3) | 20 (9.7) | 43 (15.2) | 44 (17.0) | 27 (12.0) |
| Pediatric ward | 10 (3.7) | 14 (6.8) | 24 (8.5) | 14 (5.4) | 21 (9.3) |
| Obstetric and gynecologic ward | 16 (5.9) | 5 (2.4) | 9 (3.2) | 13 (5.0) | 10 (4.4) |
| Ear, nose, throat ward | 10 (3.7) | 7 (3.4) | 17 (6.0) | 6 (2.3) | 5 (2.2) |
| Ophthalmologic ward | 2 (0.7) | 3 (1.5) | 4 (1.4) | 1 (0.4) | 3 (1.3) |
| Charlson index: n (%) | | | | | |
| 0 | 194 (71.3) | 157 (76.2) | 211 (74.6) | 190 (73.4) | 171 (76.0) |
| 1 | 39 (14.3) | 25 (12.1) | 30 (10.6) | 30 (11.6) | 26 (11.6) |
| 2-3 | 31 (11.4) | 22 (10.7) | 33 (11.7) | 32 (12.4) | 24 (10.7) |
| $\geq$ 4 | 8 (2.9) | 2 (1.0) | 9 (3.2) | 7 (2.7) | 4 (1.8) |
| Admitted in ICU: n (%) | 23 (8.5) | 26 (12.6) | 22 (7.8) | 18 (7.0) | 17 (7.6) |
| LOS: mean ± S.D. (median) (days) | 13.1 ± 13.0 (9) | 10.4 ± 9.3 (8) | 13.5 ± 15.3 (8) | 13.6 ± 17.1 (9) | 10.2 ± 9.3 (8) |
| Discharge status: n (%) | | | | | |
| Improved | 266 (97.8) | 205 (99.5) | 281 (99.3) | 258 (99.6) | 216 (96.0) |
| Not improved | 5 (1.8) | 0 | 1 (0.4) | 0 | 4 (1.8) |
| Dead | 1 (0.4) | 1 (0.5) | 1 (0.4) | 1 (0.4) | 5 (2.2) |
| Number of prescriptions by drug entities: n (%) | | | | | |
| Ampicillin | 29 (7.7) | 21 (7.5) | 24 (6.8) | 19 (5.3) | 15 (4.9) |
| Amoxycillin/clavulanic | 20 (5.3) | 19 (6.8) | 16 (4.5) | 8 (2.2) | 5 (1.6) |
| Cefazolin | 46 (12.2) | 36 (12.8) | 70 (19.8) | 73 (20.4) | 55 (18.1) |
| Ceftriaxone | 92 (24.4) | 62 (22.1) | 72 (20.3) | 97 (27.2) | 90 (29.6) |
| Ciprofloxacin | 2 (0.5) | 1 (0.4) | 12 (3.4) | 16 (4.5) | 10 (3.3) |
| Clindamycin | 4 (1.1) | 0 | 2 (0.6) | 3 (0.8) | 4 (1.3) |
| Cloxacillin | 54 (14.3) | 46 (16.4) | 53 (15.0) | 39 (10.9) | 30 (9.9) |
| Cotrimoxazole | 0 | 0 | 0 | 2 (0.6) | 0 |
| Gentamicin | 55 (14.6) | 33 (11.7) | 52 (14.7) | 36 (10.1) | 30 (9.9) |
| Metronidazole | 52 (13.8) | 46 (16.4) | 29 (8.2) | 55 (15.4) | 48 (15.8) |
| Penicillin G Sodium | 23 (6.1) | 17 (6.0) | 24 (6.8) | 9 (2.5) | 17 (5.6) |

**Table 2**. Study outcomes of the two promotion IV-oral conversion strategies

| Study outcomes | Baseline | Effectiveness of the surveillance approach | | Effectiveness of the guideline approach | |
|---|---|---|---|---|---|
| | | Immediate effect | Four-month effect | Immediate effect | Four-month effect |
| All eligible prescriptions | n = 377 | n = 281 | n = 354 | n = 357 | n = 304 |
| Incidence of converted prescriptions: n (%) | | | | | |
| All categories | 243 (64.5) | 221 (78.6) | 226 (63.8) | 254 (71.2) | 206 (67.8) |
| Sequential | 13 (22.4) | 27 (57.4) | 12 (27.9) | 37 (48.7) | 13 (21.0) |
| Switch | 230 (72.1) | 194 (82.9) | 214 (68.8) | 217 (77.2) | 193 (79.8) |
| Excess days: mean ± S.D. (median) | | | | | |
| All categories | 1.1 ± 2.5 (0) | 0.4 ± 1.0 (0) | 1.5 ± 3.0 (0) | 1.0 ± 2.4 (0) | 0.8 ± 1.7 (0) |
| Sequential | 2.2 ± 2.7 (1.5) | 1.0 ± 1.5 (0) | 2.9 ± 3.8 (2) | 1.4 ± 2.4 (1) | 2.0 ± 2.3 (1) |
| Switch | 0.9 ± 2.4 (0) | 0.3 ± 0.7 (0) | 1.3 ± 2.9 (0) | 0.8 ± 2.4 (0) | 0.5 ± 1.4 (0) |
| Potential avoidable costs: mean ± S.D. (median) | | | | | |
| All categories | 168.0 ± 546.2 (0) | 73.6 ± 231.7 (0) | 215.9 ± 506.1 (0) | 181.6 ± 625.0 (0) | 123.7 ± 331.4 (0) |
| Sequential | 314.6 ± 431.4 (209.5) | 125.0 ± 179.0 (0) | 362.2 ± 483.2 (209.5) | 375.6 ± 955.7 (116.9) | 391.2 ± 549.5 (233.8) |
| Switch | 141.3 ± 561.1 (0) | 63.2 ± 239.9 (0) | 195.6 ± 506.6 (0) | 129.1 ± 489.0 (0) | 55.2 ± 196.4 (0) |

to the long term effect of the surveillance approach.

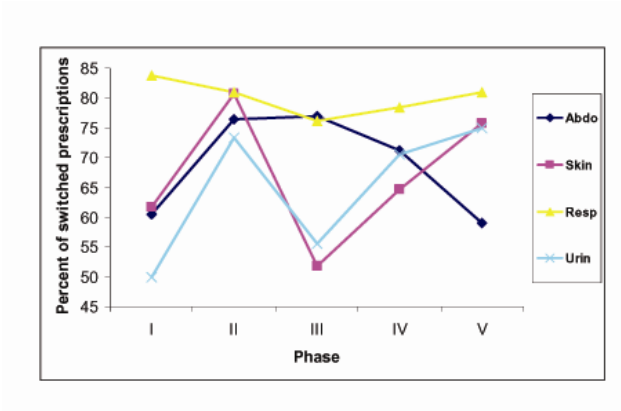
Based on the covariate-adjusted models, the surveillance approach reduced the excess days by 72% as the immediate effect only, whereas the guideline approach reduced excess days as the immediate (by 44%) and four-month effects (by 52%). For the sequential therapy category, the promoting interventions lowered the excess days as the immediate effect by 53% for the surveillance approach and by 54% for the guideline approach. For the switching therapy category, the surveillance approach lowered excess days only during the intervention period (the immediate effect) 76%, whereas the guideline approach lowered excess days in the immediate and four-month assessments by 42% and 59%, respectively.

The PACs during a 14-day review in phases I, II, III, IV and V accrued to a total of 63,325 baht ($1,809), 20,672 baht ($591), 76,414 baht ($2,183), 64,830 baht ($1,852) and 37,605 baht ($1,074), respectively. Based on the covariate-adjusted models, the surveillance approach reduced the PAC only in the immediate period by 49% for the sequential therapy and 73% for the switch therapy (Table 3). The guideline approach significantly reduced the PACs only at the four-month assessment by 55% for all prescriptions and 65% for the switching therapy category. At the four-month assessment, the PACs of the switching therapy category in the surveillance approach increased significantly as compared to the baseline.

To examine the incidences of converted prescription at the index date by site of infections, the infections with over 20 prescriptions for each phase were evaluated (Figure 1). In general, respiratory tract infections had high incidences of converted prescriptions, and the switching strategies seemed to have no effects. For both strategies, the immediate effects on increasing incidences of converted prescriptions for skin and soft tissue infection, and urinary tract infection were found. However, only the guideline approach had an effect at the four-month assessment in these two infections. For intra-abdominal infections, only the surveillance approach increased the incidence of converted prescriptions.

**Table 3.** Percentage changes of immediate and four-month effects on excess days and PACs

| Comparison with baseline | | Excess days | | | PACs | | |
|---|---|---|---|---|---|---|---|
| | | % Change | 95% CI | *p*-Value | % Change | 95% CI | *p*-Value |
| Effects of surveillance approach | | | | | | | |
| All categories (n = 1,012) | Immediate effect | -72.3 | -82.0 to -57.4 | < 0.001 | -71.1 | -82.3 to -52.8 | < 0.001 |
| | Four-month effect | 28.2 | -11.1 to 84.9 | 0.183 | 52.3 | -2.5 to 137.8 | 0.064 |
| Sequential therapy (n = 148) | Immediate effect | -52.5 | -72.3 to -18.6 | 0.007 | -49.4 | -70.8 to -12.3 | 0.015 |
| | Four-month effect | 2.2 | -36.5 to 64.3 | 0.930 | -15.6 | -47.7 to 36.2 | 0.487 |
| Switch therapy (n = 864) | Immediate effect | -75.9 | -85.4 to -60.1 | < 0.001 | -72.5 | -84.6 to -1.0 | < 0.001 |
| | Four-month effect | 30.5 | -13.1 to 96.0 | 0.199 | 73.9 | 5.7 to 186.2 | 0.029 |
| Effect of guideline approach | | | | | | | |
| All categories (n = 1,015) | Immediate effect | -43.9 | -62.9 to -15.1 | 0.006 | -34.1 | -61.4 to 12.5 | 0.127 |
| | Four-month effect | -52.1 | -67.8 to -28.7 | < 0.001 | -55.4 | -73.4 to -25.4 | 0.002 |
| Sequential therapy (n = 181) | Immediate effect | -54.4 | -72.3 to -25.0 | 0.002 | -32.3 | -60.3 to 15.5 | 0.152 |
| | Four-month effect | -32.8 | -56.3 to 3.5 | 0.071 | -8.6 | -42.9 to 46.4 | 0.709 |
| Switch therapy (n = 834) | Immediate effect | -41.7 | -63.3 to -7.4 | 0.022 | -32.5 | -62.1 to 19.9 | 0.180 |
| | Four-month effect | -59.0 | -74.1 to -35.2 | < 0.001 | -65.0 | -80.6 to -36.9 | < 0.001 |
| Comparison of effects between surveillance approach (reference) *vs.* guideline approach | | | | | | | |
| All categories (n = 638) | Immediate effect | 172.9 | 66.4 to 347.5 | < 0.001 | 237.1 | 84.9 to 514.5 | < 0.001 |
| | Four-month effect | -52.1 | -67.8 to -28.7 | < 0.001 | -55.4 | -73.4 to -25.4 | 0.002 |
| Sequential therapy (n = 123) | Immediate effect | -22.4 | -60.6 to 52.9 | 0.464 | -20.6 | -60.2 to 58.3 | 0.152 |
| | Four-month effect | -32.8 | -56.3 to 3.5 | 0.071 | -8.6 | -42.9 to 46.4 | 0.709 |
| Switch therapy (n = 515) | Immediate effect | 302.1 | 115.8 to 649.5 | < 0.001 | 416.8 | 141.0 to 1008.3 | < 0.001 |
| | Four-month effect | -59.0 | -74.1 to -35.2 | < 0.001 | -65.0 | -80.6 to -36.9 | < 0.001 |




Abdo = abdominal infection, Skin =: skin and soft tissue infection, Resp = respiratory tract infection, Urin = urinary tract infection.

**Figure1.** Incidences of converted prescriptions according to site of infections.

## DISCUSSION

This study assessed outcomes of the surveillance and the guideline approaches in promoting the IV-oral coversion of antibiotics under the Thai hospital context. During the immediate assessment, the surveillance approach increased the IV-oral coversion incidence by14%, and reduced the excess IV days and PAC by 72% and 71%, respectively. As the immediate effect, the guideline approach increased the IV-oral coversion incidence by 7% and reduced the excess IV days by 44%. At four months, the effects of surveillance approach disappeared, whereas the guideline approach was able to lower the excess IV days by 52% and reduced the PAC by 55% as a consequence. This study showed a potential cost-saving outcome of the IV-oral conversion for several antibiotics, whereas other studies have reported the intervention cost-benefit for a limited number of medications.[8,9,12-16]

This study revealed that the pharmacist-initiated, case-specific surveillance approach provided directly to individual physicians has relatively a stronger effect than the hospital-wide guideline approach that relied on an intrinsic motivation and rational information seeking of professionals. This finding seems to be congruent with a meta-analysis of prescribing interventions that reported face-to-face interventions yielded a greater effect than group interventions.[17] In this present study, the surveillance approach showed a strong effect at the moment the intervention being given, whereas the guideline approach was able to retain the outcomes even after four months. The surveillance approach probably has a short-term effect or the intervention given was in such a short period that physicians might not be well aware of the conversion potential. Even though the guideline approach duration was relatively long and most physicians got involved in the development process, the information dissemination process was passive by nature, thus had a modest stimulation on immediate prescribing change. The sustained effect of guideline approach may be explained by the fact that this approach was implemented as a local consensus policy disseminated throughout the hospital. For the intervention to be effective and sustainable, the IV-oral conversion criteria should be guided by the prescribers' mutual agreement and the external stimulus for change should be given on a continual basis.

There were certain limitations in this study. The guideline was developed for multiple drug entities and the study included all disease conditions, thereby, length of stay was not used as the measured endpoint. This study used a pre- and post-intervention design as in most studies[2,8,12,18-20] since this would not interfere the daily practice at the study site. The study hypotheses were blinded to the physicians. Thus, the present study design could not fully explain why physicians did not convert the IV therapy according to the guideline in certain candidates. A longer period than four months might be required to assess the long term effects of the guideline approach. Future studies should identify strategies that provide a sustainable and strong effect of the IV-oral conversion and explore the reasons that hinder physicians regarding IV-oral conversion for hospitalized patients.

In conclusion, both promoting strategies contributed positive economic impacts on the

IV-oral conversion of antibiotics in hospitalized patients. The benefits of guideline approach lasted longer. The surveillance approach yielded a greater but short-life benefit, thus should be implemented on a continual basis.

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**Appendix:** IV-oral conversion guideline

IV-oral switching is the conversion from intravenous to oral forms of drug administration without sacrificing the effectiveness of the drug therapy.

1. Target drugs:
   Sequential therapy category (oral antimicrobials with good bioavailability that can be switched as soon as the patient can take orally): ciprofloxacin, clindamycin, cloxacillin, cotrimoxazole, metronidazole

   Switching therapy category (medications can be converted to oral form only after the patient achieves clinical improvement): amoxycillin/ clavulanic acid, ampicillin, cefazolin, ceftriaxone, gentamicin, penicillin G

2. Criteria when to switch: A patient must meet the inclusion and none of the exclusion criteria.
   2.1 Inclusion criteria
   - Prescribed targeted IV medications > 72 hours
   - Not on completed-nil per oral
   - Able to take oral or tube fed medications
   - No gastrointestinal obstruction or malabsorption syndrome
   - Not receiving pressor therapy

   2.2 For antimicrobials other than sequential therapy, a patient should be afebrile (temperature < 37.8$^{o}$C) and hemodynamically stable (systolic blood pressure > 90 mmHg and heart rate > 100 beats/minute) more than 24-72 hours and/or improve clinically in deep neck infection, abscess in deep facial space and severe burn.

   2.3 Exclusion criteria
   - IV therapy is needed for the whole course of therapy for conditions including bacterial meningitis, bacterial endocarditis, febrile neutronpenia, severe soft tissue infections, inadequately drained abscess and empyema; or
   - Specific duration of IV therapy is indicated including melioidosis, leptospirosis, spontaneous bacterial peritonitis; or
   - Prolonged use of IV therapy is required for more than 2 weeks including bone and joint infection (*e.g.* septic arthritis, osteomyelitis) or liver abscess or endophthamitis; or
   - Sensitivity profile of hospital antibiogram had shown a resistance of oral drug; or
   - No oral medication is available for a suspected organism, *e.g.* gram negative infection in children.

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