Original Article

Quality Indicators for Prevention of Infection in the Surgical Site, the Israeli National Program for Quality Indicators Experience

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Background and Objectives: The Israeli National Program for Quality Indicators (INPQ) sets as its primary goal to promote quality health care within selected core areas in the Israeli health system**.** Surgical site infection is one of the most common sources of acquired infections. The INPQ supports 3 distinct indicators concerning suitable antibiotic treatment in colorectal surgery, cesarean sections, and surgery for femoral neck fractures. **Methods:** We measured the number of patients who received prophylactic antibiotics, beginning an hour before the first cut and stopping after 24 hours in the 3 operations, according to the *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes. Goals for success have been established annually according to the results of the previous year. Data computed for each operation included socioeconomic status, dates of hospitalization and release, date of death, date of birth, gender, date of operation, time of beginning and end of the operation, time of beginning and end of anesthesia. **Results:** Within 3 to 5 years, we achieved a significant increase in appropriate prophylactic antibiotic use from 78% to 85%, 78% to 95%, and 66% to 88% for colorectal surgery (n = 9404), cesarean sections (n = 141 362), and femoral joint operations (n = 30 728), respectively. Mortality rate was lower, 1.85% versus 0.55% in patients who received proper antibiotic therapy (odds ratio [OR] = 3.141; 95% confidence interval [CI], 1.829-5.394, $P < .0001$), 0.031% versus 0.006% (OR = 6.741; 95% CI, 1.879-21.187; $P = .003$), and 5.59% versus 4.51% (OR = 1.253; 95% CI, 1.091-1.439; $P = .001$), respectively. **Conclusion:** Prophylactic antibiotic treatment is strongly recommended by medical guidelines. The experience of the INPQ supports this approach. We can demonstrate a significant lower mortality rate in patients who have been properly treated.

Key words: cesarean section, colorectal surgery, femoral joint, indicators, national program, quality

The National Program for Quality Indicators of the Israeli Ministry of Health sets as its primary goal to promote quality health care within selected core areas in the Israeli health system, by a process of measuring the quality of care and publicizing the results to the public. This program was mandated by the law (published in 2012) and covers broad topics at the core of the Israeli health system, which include indicators for mother and baby health, prehospital care, general hospitals, geriatric hospitals, and mental health. Following 6 years of activity of the Israeli National Program for Quality Indicators (INPQ), we can summarize that there is a consistent and stable improvement in most of the indicators that were measured over the years, both within individual medical facilities and at a national level. Implementing this culture of measuring quality is felt across a wide range of the clinical continuum within the human life cycle and the fields of endeavor of the Israeli health system. A business intelligence (BI) system was developed for the program, which enables access to the program data and segmentation of the results by various characteristics, for the benefit of the program leaders and all the participants. BI is a way to reveal actionable insights in the data, find out what happened, and then explore the information.

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PREVENTION OF THE SURGICAL SITE INFECTION

Surgical site infection (SSI) is one of the most common sources of acquired infections in a hospital and one of the most common and difficult complications occurring post-surgery.[1,2] SSI causes increase in mortality rates, longer hospitalization, recurrent hospitalization and operations, and has a significant financial burden of about $3.3 billion a year, a third of the annual expenses for acquired hospital infections in the United States.[3] One of the most significant factors for reducing the risk of infection is providing suitable prophylactic antibiotics during and around surgery.[4] The purpose of this procedure is to saturate the relevant tissues in antibiotics before the first surgical cut and during the operation. Through suitable antibiotic treatment, one may reduce the risk of developing an infection upon completion of the surgery. This approach reduced 50% of SSIs and saved a significant amount of money.[5-7] The timing of treatment is very important since the maximal protection is achieved when antibiotics are given an hour before the first cut, with no advantage to continue the treatment beyond 24 hours.[4,8-11] Hospitals were ordered to improve their antibiotic administration rate. Since results were published every year, their incentive was public appreciation and recognition of excellence. Being the regulator, we did not interfere with hospital-chosen processes to achieve the indicator target.

The INPQ supports 3 distinct indicators concerning suitable antibiotic treatment for surgery in colorectal operations, cesarean sections, and surgery for femoral neck fractures. These particular operations were chosen according to high incidence of postsurgical infections (colon and rectum), potential fatal course of the infection (femoral neck fracture), or a high number of operations (cesarean section). We expected hospitals to improve and reach indicator target every year, thus improving quality and safety of the treatment. In this study, we looked at the effect of prophylactic antibiotic therapy on 3 operations: colon and rectum surgery, repair of hip fracture, and cesarean section. The 2 primary goals for our study were to identify whether Israeli hospitals made improvements over time in patients receiving antibiotics for these 3 surgical procedures, and whether the proper administration of antibiotics for patients in these 3 surgical groups had an impact on patient survival.

METHODS

Description of the 3 indicators

Prophylactic antibiotic treatment in colorectal surgery

Compliance with antibiotics: Our measure was the number of patients who received antibiotics, beginning an hour before the first surgical cut and continuing for 24 hours. The denominator included all the patients who underwent elective colorectal surgery, and the numerator included those who had been treated with antibiotics to prevent SSI. Inclusion criteria included all the patients older than 18 years who underwent elective colorectal operation according to the *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes. Exclusion criteria included patients younger than 18 years and emergency operation. The goal was 90% in 2016, 2017, and 2018.

Patient survival: We have no data about the stage of colorectal cancer (CRC) for the individual patient; thus, we cannot exclude an effect of this factor on survival. We tried to overcome this obstacle by adding age and gender to the calculation. We assumed that logistic regression model taking into account age and gender, which demonstrates a correlation between antibiotic therapy and prevention of mortality, will strengthen the results. We stratified the patients according to gender and for 5 age groups (<45, 45-54, 55-64, 65-74, and >75 years).

Prophylactic antibiotic treatment in cesarean section

Compliance with antibiotics: Our measure was the number of patients who received antibiotics, beginning an hour before the first cut and continuing for 24 hours. The denominator included all the patients who underwent cesarean section, and the numerator included those who were treated with antibiotics to prevent SSI. Inclusion criteria included all the patients who underwent cesarean section according to the *ICD-9* codes. There was no goal for the first year of measuring (2014). The goal was 80% in 2015, 90% in 2016 and 2017, and 95% in 2018.

Prophylactic antibiotic treatment in operation of femoral joint fracture

Compliance with antibiotics: Our measure was the number of patients who received antibiotics, beginning an hour before the first surgical cut and continuing for 24 hours. The denominator included all the patients who underwent repair or replacement of the femoral joint, and the numerator included those that had been treated with antibiotics to prevent SSI. Inclusion criteria included all the patients 65 years or older who underwent femoral joint repair or replacement according to the *ICD-9* codes. There was no goal for the first year of measuring (2014). The goal was 80% for 2015, 85% in 2016, and 90% in 2017 and 2018.

Patient survival: We have no data about the disease severity in the individual patient; thus, we cannot exclude an effect of this factor on survival. We tried to overcome this obstacle by adding age, gender, and time until operation to the calculation. We assumed that the logistic regression model taking into account these 3 parameters, which demonstrates a correlation between antibiotic therapy and prevention of mortality, will strengthen the results. We stratified the patients according to gender, 6 age groups (65-69, 70-74, 75-79, 80-84, 85-89, and >90 years), and 4 groups of different waiting time to operation (0, 1, 2, and 3 or more days).

Measuring

Data computed for each case were the number of admission, date of hospitalization, date of discharge, year of birth, date of death, gender, date of operation, time of beginning and end of the operation, and time of beginning and end of anesthesia. We could separate patients who received prophylactic antibiotics before surgery and those who had not. The antibiotic used was usually cefazolin.

Validation

Indicators' results were reported every 3 months to a dedicate server of the INPQ. Data were examined for accuracy by independent observers before acceptance into the server. Senior nurses and investigators then validated a statistically calculated sample of the reported indicators, and upon initial approval referred it for statistical evaluation and final approval.

Comparison and publication

Hospitals have been compared every year according to indicators' results, and national achievements were computed every year. Indicators' goals increased according to hospitals' achievements. The annual results were published in the media and presented at an annual meeting.

Statistical methods

In each of the 3 operations—colorectal, cesarean section, and femoral joint fracture—we looked at changes along time in the indicator achievement, and the 30-day mortality of the specific procedure, comparing the patients who received prophylactic antibiotics properly and those who did not. To overcome the lack of information about diseases severity, we added a logistic regression model taking into account 3 parameters—age, gender, and time to operation (in femoral joint fracture)—looking for a correlation between antibiotic therapy and prevention of mortality that will strengthen the results. We stratified the patients according to gender, age groups, and groups of different waiting time to operation.

RESULTS

Prophylactic antibiotic treatment in colorectal surgery

Compliance with antibiotics: Measuring of the indicator of prophylactic antibiotic treatment in elective colorectal surgery started in 2016 with 2877 operations and a 78% success rate (Figure 1). The following [F1]
figures for the years 2017 and 2018 were 3212 cases with an 83% success rate and 3315 cases with an 85% success rate, respectively (Figure 1A). Treatment was started before the first surgical cut in 93%, 94%, and 95%, and stopped after 24 hours in 80%, 85%, and 86%, in 2016, 2017, and 2018, respectively (Figure 1B). Nine hospitals out of 24 (37.5%) reached the annual goal of 90% in 2018.

Patient survival: Since 2016 up to 2018, 9404 patients underwent colorectal surgery. Of these, 7736 were treated on time with prophylactic antibiotics and 1668 were not. The mortality rate within 30 days of the operation was 0.55% in the first group and 1.85% in the second group, with an odds ratio (OR) of 3.141 (95% confidence interval [CI], 1.829-5.394; $P < .0001$; Figure 1C). According to the logistic regression model, the OR for mortality was 0.624 ($P = .06$) for women who were not treated with antibiotics (in comparison with men who were not treated), and 25.439, 6.623, 4.363 ($P < .0001$) for patients in the higher age groups in comparison with the group of younger than 45 years, respectively ($c = 0.81$).

Prophylactic antibiotic treatment in cesarean section

Compliance with antibiotics: Measuring the indicator for prophylactic antibiotic treatment in cesarean sections started in 2014 with 21 607 operations and a 78% success rate (Figure 2A). The following [F2]
figures for the years 2015, 2016, 2017, and 2018 were 29 500 cases with an 88% success rate, 29 739 with a 93% success rate, 3 076 cases with a 95%

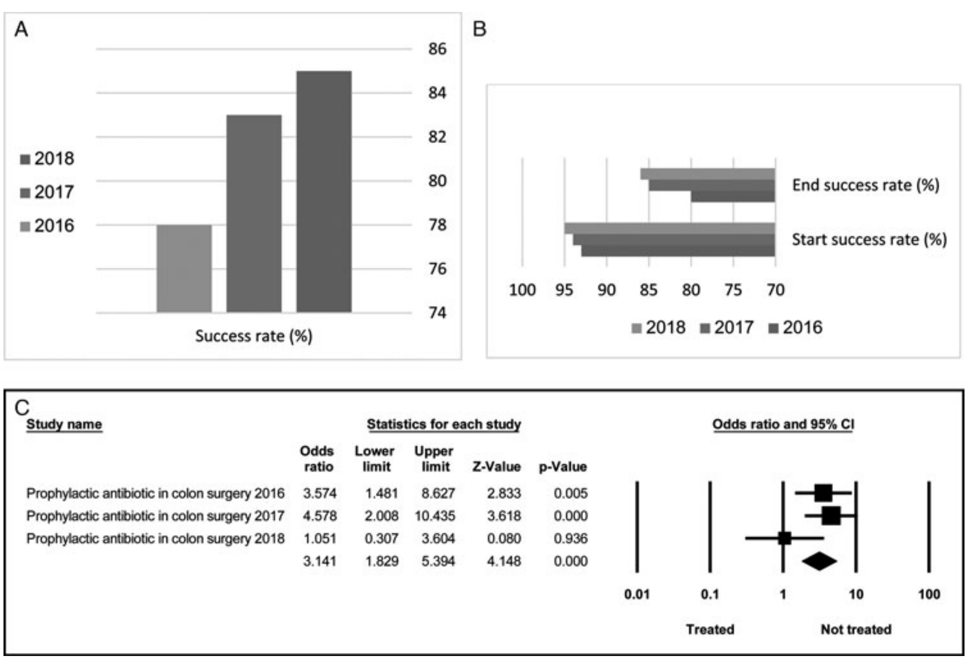

Figure 1. Prophylactic antibiotic treatment in elective colorectal surgery (n = 9404). (A) Comparison of success rates from 2016 to 2018. (B) Comparison of success rates in start and end (after 24 hours). (C) Comparison of mortality between patients treated and not treated.

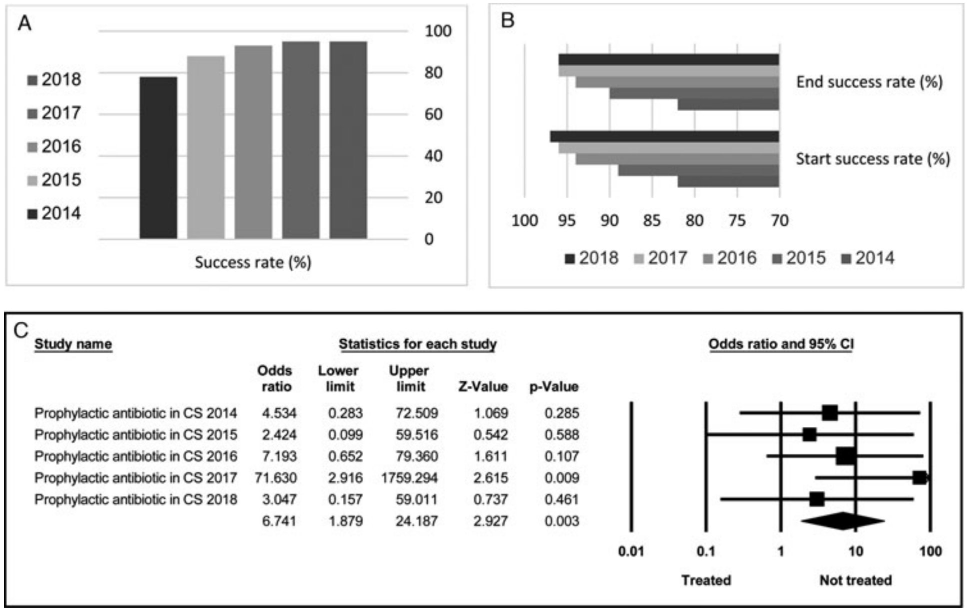

Figure 2. Prophylactic antibiotics in cesarean section (n = 141 362). (A) Comparison of success rates from 2014 to 2018. (B) Comparison of success rates in start and end (after 24 hours). (C) Comparison of mortality between patients treated and not treated.

success rate, and 30 440 cases with a 95% success rate, respectively. Treatment was started before the first surgical cut in 82%, 89%, 94%, 96%, and 97%, and stopped after 24 hours in 82%, 90%, 94%, 96%, and 96%, in 2014, 2015, 2016, 2017, and 2018, respectively (Figure 2B). Nineteen hospitals out of 26 (73.0%) reached the goal of 95% in 2018.

Patient survival: Since 2014 to 2018, 141 362 patients underwent cesarean section. Of these 128 418 were treated on time with prophylactic antibiotics and 12 944 were not. The mortality rate within 30 days of the operation was 0.006% in the first group and 0.031% in the second group with an OR of 6.741 (95% CI, 1.879-21.187; $P = .003$; Figure 2C).

Prophylactic antibiotic treatment in operation of femoral joint fracture

Compliance with antibiotics: Measuring the indicator for prophylactic antibiotic treatment in femoral joint repair or replacement started in 2014 with 5601 op-
[F3] erations and a 66% success rate (Figure 3A). The following figures for the years 2015, 2016, 2017, and 2018 were 5922 cases with a 76% success rate, 6247 with an 86% success rate, 6480 cases with an 87% success rate, and 6478 cases with an 88% success rate, respectively. Treatment was started before the first cut in 83%, 89%, 94%, 95%, and 95%, and stopped after 24 hours in 70%, 80%, 89%, 89%, and 89%, in 2014, 2015, 2016, 2017, and 2018, respectively (Figure 3B). Fifteen hospitals out of 26 (57.7%) reached the goal of 90% in 2018. The lower success rate was achieved for morning operation than for evening and night operations (53%, 66%, 81%, 78%, and 77% vs 65%, 78%, 87%, 89%, and 90% for 2014, 2015, 2016, 2017, and 2018, respectively). In 2018, the lower success rate was found for total hip replacement versus partial replacement or fixation (80%, 87%, and 90%, respectively). Lower success rates were found in peripheral (>200 km from Tel Aviv) versus central hospitals (42%, 64%, 81%, 78%, and 78% vs 68%, 80%, 88%, 90%, and 91% for 2014, 2015, 2016, 2017, and 2018, respectively).

Patient survival: Since 2014 to 2018, 30 728 patients underwent femoral joint repair or replacement. Of these 24 919 were treated on time with prophylactic antibiotics and 5809 were not. The mortality rate within 30 days of the operation was 4.51% in the first group and 5.59% in the second group, with an OR of 1.253 (95% CI, 1.091-1.439; $P = .001$; Figure 3C). According to the logistic regression model, the OR for mortality was 0.474 ($P = 0.06$) for women who were not treated with antibiotics (in comparison with men who were not treated), 5.711, 3.380, 2.508, and 2.097 ($P < .0001$) for patients in the higher age groups in comparison with the group of 65 to 69 years old, and 2.086, 1.476 for 2 or 3 days' time to operation in comparison with 0 day, respectively ($c = 0.68$).

DISCUSSION

In 2012, the Minister of Health of Israel decided to establish a National Program for Quality Indicators. After an act of legislation the program was started with 5 quality indicators without any target. After a year, and according to hospitals performance, targets were set for every indicator, and increased every year since that time. A BI system was developed and the results were digitally extracted quarterly, validated and published. Every year, since 2013, indicators were added by expert committees, according to well-validated methods.

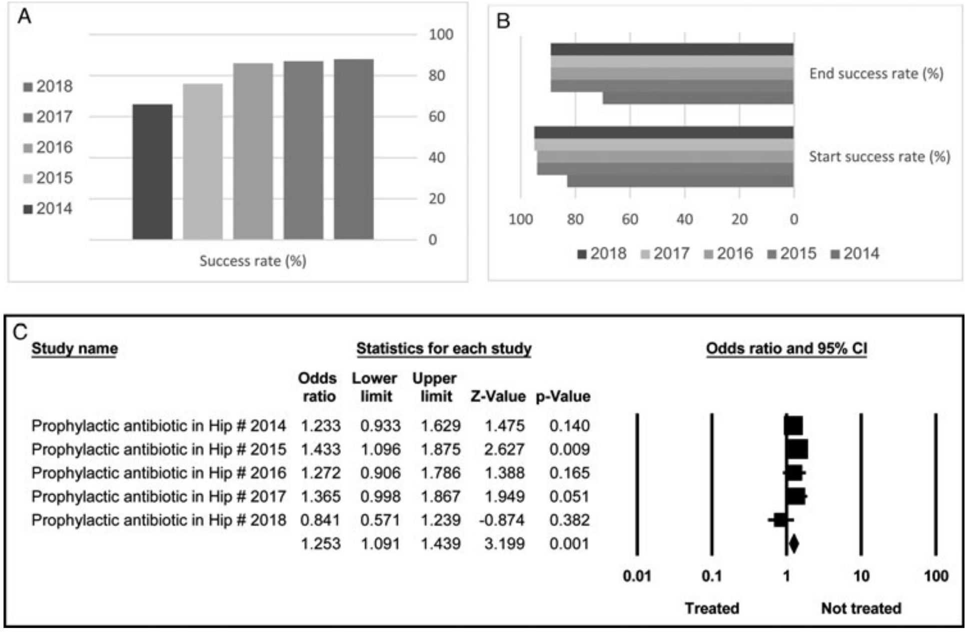

Figure 3. Prophylactic antibiotics in hip joint replacement or repair (n = 30 728). (A) Comparison of success rates from 2014 to 2018. (B) Comparison of success rates in start and end (after 24 hours). (C) Comparison of mortality between patients treated and not treated.

A periodic questionnaire distributed in Israeli hospitals examines participants' satisfactions, and corrections are continuously performed. Hospitals improve their antibiotic administration regimens by performing specific processes. Even though an impressive improvement was presented by most of the care givers, still variation in success exists. Those who still need improvement are noticed and inspected. We believe that quality managers in other countries will find our results interesting, since correlation of success in indicators programs, evidence for improved treatment goals and reduced mortality, will be of help in design and activation of such programs all over the world.

The main goal of prophylactic antibiotics in surgical procedures is to prevent SSI. Since we are not measuring this in our NPQI, we cannot compare our results to the literature. We could found though a lower mortality rate (probably through sepsis prevention) in patients who received proper antibiotic therapy versus in patients who did not.

Prophylactic antibiotics in colorectal surgery

The rate of SSI after colorectal surgery is higher than most of the major operations, being 1% to 25%.[12-19] In a Cochrane systematic review of 43 451 patients who underwent colorectal surgery, prophylactic antibiotic decreased the SSIs in 75%.[20]

Within 3 years, we achieved a significant increase in a proper prophylactic antibiotic use from 78% to 85%. Thirty-day mortality was 1.58% in patients who received proper antibiotic therapy versus 0.55% in patients who did not. An improvement is still needed, especially with stopping the prophylactic treatment after 24 hours.

Prophylactic antibiotics for cesarean section

The rates of SSI after cesarean section are 2% to 10%.[21-24] In Europe the rate of SSI is lower (0.2% -2.2%).[18] The risk factors for SSI are subcutaneous bleeding, long cut of more than 16.6 cm, a body mass index of more than 30 kg/m^2, steroid treatment, smoking, and no use of a prophylactic antibiotic.[24] A Cochrane systematic review of 95 studies with 15 000 women revealed a 60% decrease in SSI and a 62% decrease in endometriosis after prophylactic antibiotics.[25] When only elective cesarean sections were considered, these rates were 40% and 62%. Giving the prophylactic treatment for more than 24 hours had no advantage.[26] Within 5 years, we achieved a significant increase in proper prophylactic antibiotic use from 78% to 95%, and a lower 30-day mortality.

Prophylactic antibiotics in hip joint replacement or repair

Giving prophylactic antibiotics before femoral neck joint repair or replacement decreased SSI in 0.4% to 11.4%.[18,27-29] A meta-analysis found a decrease of 60%.[30] Within 5 years, we achieved a significant increase in a proper prophylactic antibiotic use from 66% to 88%, and a lower 30-day mortality, from 5.59% to 4.51%. An improvement is still needed, especially in stopping the prophylactic treatment after 24 hours, being 89% in 2018. We could not explain the differences between morning and evening operations, nor among different surgical approaches. We found differences between peripheral and central hospitals in Israel, which should be thoroughly investigated and corrected.

Our study has limitation related to using an epidemiological approach to study clinical issues. We could not know the causes of mortality, nor establish a cause-and-effect pattern between mortality and successful antibiotic therapy. In addition, we had no information on the severity of the disease, yet we succeeded demonstrating in a logistic regression model, a correlation between 3 independent factors (gender, age, and time to operation) and mortality rates. More than that, the consistent decrease in mortality, every year, in patients who received proper antibiotic therapy, comparing to patients who did not, supports a cause-and-effect pattern every year, and in the total duration of measuring.

In summary, antibiotic prophylactic treatment in elective colorectal surgery, cesarean section, and femoral joint replacement or repair is strongly recommended by guidelines in the United States and Europe, and by the Israeli Ministry of Health.[4,9] The experience of the INPQ supports this approach. We could demonstrate a significant decrease in mortality in patients who have been treated. [AQ2]

[AQ3]

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Queries to Author

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Author: Yaron Niv, Michael Kuniavsky, Olga Bronshtein, Nethanel Goldschmidt, Shuli Hanhart, David Levine, Hannah Mahalla - OK
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