Assessing the Impact of a Pertussis Active Surveillance Program on Provider Testing Behavior, Minnesota 2005–2009

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Objectives. The Minnesota Department of Health, in collaboration with the Centers for Disease Control and Prevention, implemented the Pertussis Active Surveillance Project to better understand pertussis epidemiology. We evaluated the program's impact.

Methods. Clinics in 2 counties were offered free diagnostic testing and an educational presentation covering pertussis epidemiology. Clinics were identified as either active or intermittent, with active clinics testing 33% or more of the total number of months enrolled. We used generalized estimating equations to assess changes in provider testing behavior over the project period.

Results. Ninety-seven clinics enrolled, with 38% classified as active. Active clinics were more likely to use the state lab for diagnostic testing and had a larger staff. During the project period, a decline in days coughing at the time of visit occurred in both jurisdictions.

Conclusions. Providing clinics with free diagnostic testing influenced their participation levels. Among active clinics, results suggest changes in provider testing behavior over the course of the project. However, given the lack of robust participation, this resource-intensive strategy may not be a cost-effective approach to evaluating trends in pertussis epidemiology. (*Am J Public Health.* 2014;104:e34–e39. doi:10.2105/AJPH.2013.301815)

Pertussis, or whooping cough, is a communicable respiratory disease caused by the Gram-negative coccobacillus *Bordetella pertussis.* Although the disease is vaccine preventable, it remains endemic in the United States, with cyclical peaks occurring every 3 to 5 years.[1] Since the 1980s, incidence rates of pertussis have been rising in all age groups,[1–5] with adults and adolescents experiencing significant increases.[6] Paralleling national trends in pertussis activity, Minnesota reported a peak period in 2004 that continued into 2005 with an average yearly rate of 29.2 per 100 000 cases. A subsequent peak period started in 2008 that continued into 2010 with an average annual rate of 20.9 per 100 000 cases.[7] Minnesota experienced a shift in the median age between these 2 peak periods, from 13 to 11 years.

Although reportable in all states, pertussis frequently goes unrecognized.[4,8–10] Provider knowledge regarding pertussis epidemiology and clinical practice is inconsistent, limiting the reliability of passive surveillance systems to accurately capture disease incidence.[11] The natural progression of the disease, beginning with nonspecific upper respiratory system symptoms and ending with a persistent paroxysmal cough, creates an ambiguous clinical picture for the purpose of diagnosis.[5,12] This is especially true for adults and adolescents, in whom disease presentation may be mild, atypical, or difficult to differentiate from other upper respiratory tract infections.[4,8,11–13] Studies have indicated that 12% to 32% of adults and adolescents with a cough of unknown etiology lasting 1 to 2 weeks are seropositive for pertussis.[14] For these reasons, national and statewide estimates of pertussis incidence may be greatly underestimated.[6,11,15,16]

In an effort to address the issues around provider awareness and underreporting of pertussis, the Minnesota Department of Health (MDH) collaborated with the Centers for Disease Control and Prevention and 2 local public health agencies on an initiative to increase recognition and testing of suspect pertussis cases through education and free pertussis testing incentives. This initiative, the Pertussis Active Surveillance Project (PASP), ran from 2005 to 2009 (51 months total). We report here the results of a program evaluation of PASP, focusing on the factors associated with clinic participation and changes in provider testing behavior over time.

METHODS

We selected Dakota and Ramsey Counties because of the diverse demographic populations that their clinics serve; Ramsey County is predominately urban, and Dakota County is a combination of suburban and rural areas. The 2 counties complement each other with varying racial, ethnic, and socioeconomic demographics. The implementation of PASP was staged and included pilot, expansion, and maintenance phases.

Data Collection

From July 2005 through March 2006, local public health staff identified key contacts at pilot clinics to assess and resolve implementation challenges. From September 2006 through December 2007, project planners attempted to recruit all outpatient health care facilities in Dakota and Ramsey Counties. Recruited sites included independent clinics, large health systems, and school- and college-based clinics. Participating sites were provided videotapes or DVDs demonstrating proper specimen collection procedures, quick references summarizing project protocols, and pertussis testing and treatment recommendations. Each site was offered an in-person presentation that included information about the program as well as an overview of the epidemiology and clinical features of pertussis. Sites could select from among several presentation formats. The full-format option included a 1-hour in-person presentation that staff members at all professional levels were encouraged to attend. The second option was a partial flexible format that included anything from a one-on-one discussion with the clinic point person to an electronic distribution of the PowerPoint version 8.0 (Microsoft, Inc., Redmond, WA) presentation for providers to review independently. Continuing medical education credits were available for health care providers who attended the full-format presentation.

To encourage earlier recognition and testing, providers were asked to collect a specimen along with clinical and epidemiological information on each patient who met at least 1 of the screening criteria. The criteria were as follows: (1) a persistent cough of unknown etiology lasting 14 or more days; (2) paroxysmal cough, whoop, posttussive vomiting or gagging, or apnea with a cough lasting 7 or more days; (3) a cough of unknown etiology in a patient who has been notified of an exposure to pertussis; or (4) any patient in whom the provider suspects pertussis. The provider was asked to fill out a PASP form marking the associated symptoms along with demographic, epidemiologic, vaccination, and antibiotic treatment history. This form allowed for collection of data on symptoms at the time of visit, as opposed to at the time of case investigation. Concurrent with the PASP form, providers were asked to submit a specimen to either the Minnesota Department of Health–Public Health Laboratory (MDH-PHL) or to the clinic's reference laboratory.

Specimens submitted to the MDH-PHL were tested by polymerase chain reaction (PCR) and culture at no cost to the clinic. Nasopharyngeal swabs were used for specimen collection; specimens sent to MDH-PHL were transported on Regan-Lowe agar to support culture growth. Specimens sent to other reference laboratories were generally tested for pertussis by PCR only. Platforms for PCR vary by laboratory, but laboratories used by Minnesota providers generally use the DNA insertion sequence IS481 to identify *B. pertussis* and IS1001 for *Bordetella parapertussis*, including the MDH-PHL.

The last phase of the project ran from January 2008 to September 2009. During this phase, enrolled clinics continued testing and submitting PASP forms to MDH. Communication with sites was maintained throughout the project via semiannual newsletters to all participating clinics with information regarding project progress as well as updates on pertussis vaccine recommendations and epidemiological trends. Providers were audited quarterly to monitor reporting and testing participation.

Statistical Analysis

We performed all data cleaning and analyses using SAS version 9.2 (SAS Institute Inc., Cary, NC).[17] During the expansion and maintenance period, we calculated pertussis annual cumulative incidence for Dakota and Ramsey Counties and the remainder of Minnesota using intercensal data obtained from the US Census Bureau's Population Division for 2006–2009.[18]

To assess differences in project participation, we divided clinics into 2 categories, active and intermittent participation, on the basis of the proportion of the number of months in which 1 or more PASP forms was submitted over the clinic's total enrollment period. Active clinics were defined as clinics that submitted PASP forms 33% or more of the total number of months they were enrolled; intermittent clinics, as those that submitted PASP forms less than 33% of that period. In determining the 33% cutoff for active clinics, we examined submission patterns from all clinics (mean = 0.33 tests per month; median = 0.26). We set the cutoff relatively low for the active category considering the seasonality and cyclical nature of pertussis.

We used descriptive statistics to summarize and compare site characteristics among active and intermittent clinics and performed univariate analyses to assess differences in training participation, MDH-PHL use, and general clinic traits. We used two-tailed Wilcoxon–Mann-Whitney and Fisher exact tests to evaluate differences in distributions and proportions.

We used the generalized estimating equations (GEE) method to analyze changes in provider testing behavior over time. Because of the sample size requirements for GEE analysis, evaluation was limited to those clinics that tested at least 5 times during their participation in the project. We chose the GEE method for its ability to account for correlations within clusters.[19,20] Using data from active clinics only, we performed univariate logistic regression with study month (1–51 months of the study) as the predictor variable and age at time of visit, number of days coughing at time of visit, antibiotic prescription, provider diagnosis, and reason for testing (RFT) variables as the outcome variables. We created four RFT variables in SAS by matching clinical presentation at the time of the patient's visit with the established testing criteria. Because of the inability to reliably calculate RFT variable 4 (provider suspicion of pertussis), we excluded it from the final analysis.

For the GEE analysis, we divided active clinics into subgroups on the basis of county and time of enrollment. Time-of-enrollment subgroups included (1) clinics that enrolled during the pilot phase of the project and (2) those that enrolled during the expansion and maintenance phases. We did this to control for a large pertussis outbreak that occurred in Dakota County during the maintenance phase and also to account for the fact that recruitment materials were still evolving during the pilot phase.

RESULTS

A total of 97 clinics participated in PASP; of these, 13 were outside county borders but were affiliated with a clinic within county borders. Some clinics agreed to participate only if the affiliated clinic (sometimes located outside of the county borders) also participated. For the purposes of evaluating predictors of participation and behavior change, we combined affiliated clinics within and outside the county borders and assigned them to either Dakota or Ramsey County.

Descriptive Analysis

The response rate for clinic enrollment was 61% (97 of 159 clinics) within the 2 county jurisdictions. Of the 97 enrolled clinics, 51 were assigned to Dakota County and 46 were assigned to Ramsey County. Of these, 23 were enrolled during the pilot phase. Participating sites consisted of 52 (54%) general practice, 19 (20%) pediatric, 12 (12%) school-based, 9 (9%) college-based, 2 (2%) urgent care, 2 (2%) hospitals, and 1 (1%) adult care only. Of the 62 clinics that declined to participate in the study, 23 agreed to display project materials in their clinic.

The majority (60; 62%) of clinics enrolled in the study were classified as intermittent clinics (including those clinics that were enrolled but did not submit PASP forms), although active clinics (37; 38%) submitted the majority of PASP forms. Total time enrolled in the project ranged from 10 to 51 months for all clinics (18–51 months for active clinics and 10–50 months for intermittent clinics). Of the 97 clinics enrolled in the study, 90 reported testing 1 or more patients during the study period with a range of 1 to 533 per clinic (median = 163; mean = 223). Seven enrolled clinics did not submit a single PASP form during their enrollment. Reasons given by clinics that did not submit PASP forms during an audited 3-month period included no patients matching pertussis-like symptoms, staff turnover resulting in loss of project knowledge, and discontinuation of the project. Clinic characteristics can be viewed in Table 1.

Enrolled clinics submitted 4497 PASP forms to MDH, each representing a unique patient visit and test. Of the 4497 patients tested, 321 (7%) were PCR positive for pertussis and 130 (40%) of those were also positive by culture. Additionally, 38 (< 1%) were PCR positive for parapertussis, 7 (< 1%) were indeterminate, 3 (< 1%) were unsatisfactory, 1 (< 1%) had unknown results, and 4127 (92%) were negative for both pertussis and parapertussis. In 2008, Dakota County experienced an outbreak of pertussis, which accounted for 1874 (51%) of the total 3659 specimens collected from Dakota County during the entire project.

TABLE 1—Clinic Characteristics: Pertussis Active Surveillance Project, Minnesota, 2005–2009

Characteristics	No. (%)
Submitted ≥ 1 tests	90 (93)
Enrolled during the pilot phase	23 (24)
Enrolled during the expansion/maintenance phases	74 (77)
Tested ≥ 33% of mo (active)	37 (38)
Tested < 33% of mo (intermittent)	60 (62)
Dakota County jurisdiction	51 (53)
Ramsey County jurisdiction	46 (47)

Note. Of 159 clinics, 97 (61%) were enrolled in the Pertussis Active Surveillance Project.

We identified a significant difference between active and intermittent clinics in total clinic staff size, total number of physicians, and use of MDH-PHL (Table 2). In general, active clinics were larger ($P < .01$), had more physicians ($P = .01$), and tended to use the MDH-PHL for testing ($P = .03$). In addition, we found it suggestive that active clinics were more likely than intermittent clinics to have had full-format educational training ($P = .08$). Sites classified as active in Dakota County included 15 (56%) general practice, 8 (30%) pediatric, 2 (7%) hospitals, 1 (4%) college-based, and 1 (3%) urgent care site; Ramsey County included 4 (40%) pediatric, 3 (30%) general practice, and 3(30%) college-based sites.

The annual cumulative incidence of pertussis during the PASP period in Dakota County ranged from 1.55 to 91.14 per 100 000; in Ramsey County, from 0.80 to 10.54 per 100 000; and in the remainder of Minnesota, from 1.36 to 19.71 per 100 000. Incidence in Dakota and Ramsey Counties decreased in the year that the project stopped, whereas the remainder of Minnesota continued to see an increase in reported incidence. See Figure 1 for rates by year and geographical area.

Generalized Estimating Equations Outcomes

Of the 37 active clinics, 7 were recruited during the pilot phase (4, Ramsey; 3, Dakota) and 30 were recruited during the expansion and maintenance phases (6, Ramsey; 24, Dakota). Owing to the small number of clinics eligible for GEE calculations during the pilot phase in both counties, we excluded data from this period of the project from the analysis. The expansion and maintenance period used in the GEE analysis spanned 37 months (September 2006–September 2009). The majority of active clinics were under the jurisdiction of Dakota County (27; 73%). Among those clinics that submitted 5 or more specimens during the project period, data on 4441 patient visits and tests were available for GEE analysis.

In Dakota County, active clinics enrolled during the expansion and maintenance phases experienced a significant decrease in the number of days coughing at the time of visit ($P \le .001$) over the span of the project (Table 3). Providers were therefore testing patients earlier in the course of their cough illness. RFT variable 1 (a persistent cough of unknown etiology for ≥ 14 days) and RFT variable 2 (pertussis-like symptoms along with a cough for ≥ 7 days) decreased (both, $P \le .001$), whereas RFT variable 3 (a cough of unknown etiology and also exposed to a known case of pertussis) increased ($P \le .001$). The significant reduction in RFT variables 1 and 2 accompanied by the increase in RFT variable 3 indicates that providers were testing more patients because of a recent pertussis exposure than because of lingering symptoms.

Ramsey County's active clinics enrolling during the expansion and maintenance phases had a significant decrease in age at time of visit ($P = .002$) and number of days coughing at time of visit ($P = .01$), meaning that over the course of the study, clinics in this group tested younger patients with a shorter cough duration at the time of their clinic visit.

DISCUSSION

We assessed factors associated with clinic participation in PASP and evaluated changes in provider testing behavior among sites that were categorized as active. Findings suggest that larger staff size and choosing to use MDH-PHL for testing were factors associated with being an active clinic. Clinics with larger staff sizes may have had better infrastructure in place to maintain knowledge and awareness of the project over time among staff members. Although clinics with larger staff size may have had more patients to test, the cutoff criterion for an active clinic was to submit at least 1 test per month for one third of the total months enrolled. The possibility of not having any patients presenting with a cough lasting longer than a week, even in small clinics, seems unlikely.

In addition to examining factors influencing clinic participation in the project, we also analyzed provider testing behavior over time. The reduction in days coughing at time of patient visit in both counties suggests that health care providers were testing patients earlier in the course of their illness during the

TABLE 2—Characteristics of Active and Intermittent Clinics: Pertussis Active Surveillance Project, Minnesota, 2005–2009

Characteristics	Active (n = 37), No. (Range) or No. (%)	Intermittent (n = 60), No. (Range) or No. (%)	*P*
Total staff	65 (3-642)	30 (2-391)	< .01
Staff, non-MD	2 (0-7)	7 (0-308)	.558
Staff, MD–DO	14 (0-230)	6 (0-72)	< .011
Participated in full training	37 (100)	54 (90)	.08
Used MDH testing	33 (89)	41 (68)	.026

Note. MDH = Minnesota Department of Health.

study, which is consistent with the project's goal of encouraging earlier recognition of pertussis. Although strict adherence to the testing criteria during this project would have precluded a change in duration of cough at time of specimen collection, uptake to new recommendations tend to evolve over time. The outbreak in Dakota County could have contributed to earlier testing; however, we saw a similar trend of earlier testing in Ramsey County where no widespread outbreaks were reported, thus suggesting the decrease in days coughing at time of patient visit was not solely in response to the outbreak.

Active clinics in Ramsey County that enrolled during the expansion and maintenance phases tested younger patients over time. Although caution must be taken in interpreting Ramsey County's overall GEE results because of the small sample size, the significant reduction in age of patients tested parallels the downward shift in the median age of pertussis cases that occurred in Minnesota over the same period. For example, in Minnesota the median age of pertussis cases was 13 during the 2004–2005 peak period and 11 during the 2008–2010 peak period. Although the decrease in the median age of pertussis cases was statewide, the 2008–2009 pertussis outbreak in Dakota County may have influenced clinics to test patients of a much wider age range because we found no change in the outcome variable age at time of visit in Dakota County's active testing clinics. In addition, we found no difference in age distribution between the counties' general population.[18]

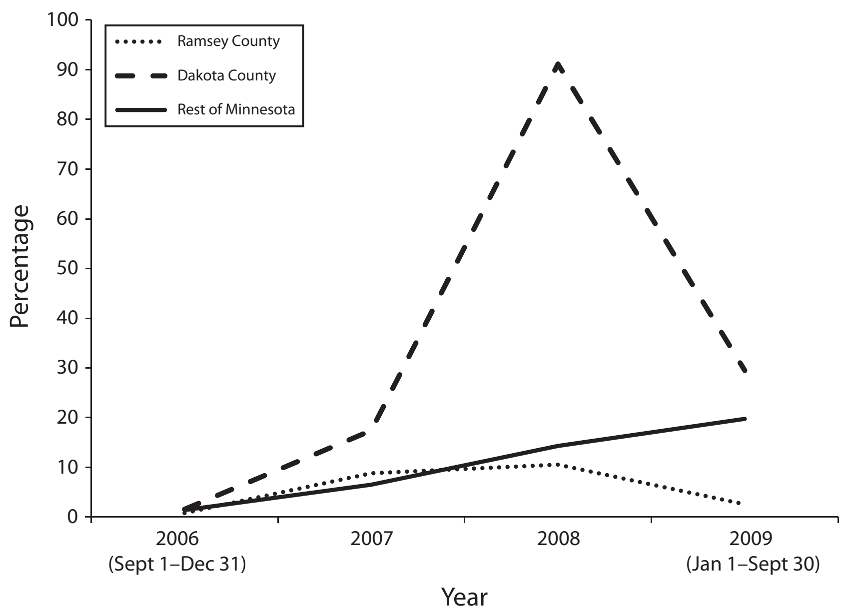

FIGURE 1—Pertussis rate by year and geographical area: Pertussis Active Surveillance Project, Minnesota, 2005–2009.

Dakota County saw an increase in testing among active clinics that enrolled during the expansion and maintenance phases for those who had contact with a known case of pertussis (RFT variable 3), but a decrease in those presenting with other clinical symptoms consistent with pertussis (RFT variables 1 and 2). The trends in Dakota County could be related to the increased testing and provider awareness resulting from the 2008–2009 pertussis outbreak in that county, accounting for the increase seen in providers evaluating patients associated with a known exposure. The simultaneous decrease in patients presenting with other pertussis-like symptoms is intuitive because outbreak notifications might prompt earlier patient visits with mild or fewer clinical symptoms of pertussis. We observed no significant differences in RFT variables in Ramsey County, suggesting a consistent testing pattern and familiarity level for clinics enrolled during the expansion and maintenance phases of the project.

Dakota County had consistently higher rates of pertussis than the rest of the state; however, Ramsey County had rates higher than the rest of the state for only 1 year. The project was started during a period of relatively low pertussis incidence in Minnesota (2006–2007), followed by an outbreak period that predominantly affected Dakota County (2008–2009). Measuring the true impact of the project on Dakota County providers was limited by the outbreak; however, the outbreak may also have had the effect of increasing provider awareness and familiarity with pertussis testing and treatment protocols. Furthermore, the PASP initiative may have enhanced detection of cases during the outbreak as a result of continuing education and support of health care providers.

The decrease in pertussis rates in Dakota and Ramsey Counties for 2009 could be attributed to the project ending and clinics tapering off or to the natural cycle of pertussis. As mentioned, Dakota County had experienced an outbreak the year before, so a lower incidence period in 2009 would be somewhat expected. Minnesota continued to see

TABLE 3—Generalized Estimating Equation Results With Study Month as Predictor for Active Clinics Recruited During the Expansion and Maintenance Phases: Pertussis Active Surveillance Project, Minnesota, 2005–2009

Variables	Estimate (95% CI)	Pr > Z[a]
Outcome variables		
Age at time of visit[b]		
Dakota County	-0.004 (-0.015, 0.006)	.423
Ramsey County	-0.024 (-0.039 -0.009)	.002
Days coughing at time of visit[c]		
Dakota County	-0.017 (-0.026, -0.008)	≤ .001
Ramsey County	-0.019 (-0.034, -0.005)	.01
Were antibiotics prescribed?		
Dakota County	0.012 (-0.007, 0.032)	.205
Ramsey County	0.016 (-0.025, 0.058)	.446
Did the provider diagnose pertussis?		
Dakota County	0.000 (-0.014, 0.014)	.995
Ramsey County	-0.017 (-0.059, 0.025)	.426
Reasons for testing[d]		
A persistent cough of unknown etiology for ≥ 14 d		
Dakota County	-0.042 (-0.064, -0.012)	≤ .001
Ramsey County	-0.009 (-0.034, 0.016)	.48
A paroxysmal cough, whoop, posttussive vomiting or gagging, or apnea with cough for ≥ 7 d		
Dakota County	-0.038 (-0.054, -0.022)	≤ .001
Ramsey County	0.005 (-0.027, 0.037)	.759
A cough of unknown etiology and been notified of a pertussis exposure		
Dakota County	0.069 (0.047, 0.092)	≤ .001
Ramsey County	0.051 (-0.035, 0.136)	.247

Note. CI = confidence interval; GEE = generalized estimating equations.
[a]$P < .05$ was considered significant.
[b]Age was modeled using a γ distribution.
[c]Days coughing was modeled using a Poisson distribution.
[d]Binary variables, modeling on the probability that the variable value = 1 or "yes."

increased reports of pertussis circulate throughout the state into 2010, ending the statewide 3-year peak period.

Considerations for Active Surveillance

Although a change in provider testing occurred among active clinic participants, the smaller number of active clinics involved (37) in contrast to the number of intermittent clinics (60) suggests that establishing active surveillance for pertussis using this type of educational intervention was not fully achieved. The moderate response rate for enrollment (97 of 159, or 61%) and the low levels of participation for the majority of enrolled clinics imply that the project was overall not successful in creating a uniform system to regularly consider pertussis in the differential diagnoses of children, adolescents, and adults. Furthermore, the analysis was limited in that we were unable to obtain testing patterns before the initiation of this project. This comparison would have allowed us to assess changes in testing behavior more accurately.

Developing and maintaining health care provider awareness of pertussis epidemiology and clinical issues involved the collaborative work of multiple organizations and agencies (i.e., local public health agencies, clinics, and state public health organizations). This resource-intensive strategy should be weighed against other less costly methods and the critical nature of the desired outcome. Yet because of this resource-intensive strategy, relationships among clinics, state, and local public health agencies were strengthened. Clinic-level education on disease reporting and the role of public health investigations enhanced providers' understanding of these topics, as well as the resources available at local and state health departments.

Conclusions

Through implementation of this active surveillance program, we were able to change some provider testing behavior in Dakota and Ramsey Counties. The impact of the education and networking component of this project has extended beyond pertussis. The resources developed for pertussis continue to be used, including the adaptation of posters and methods by other states. This project was designed to increase provider knowledge and awareness of pertussis in Dakota and Ramsey Counties, which it achieved; it also proved to be instructive in identifying methodologies for communicating with and providing guidance to providers. However, we also found that given the lack of robust participation, this resource-intensive strategy may not be a cost-effective approach to evaluate trends in pertussis epidemiology. Regardless, the fluctuating nature of pertussis disease incidence and epidemiology remains a formidable challenge for public health and health care professionals alike and warrants continued efforts to improve surveillance methods and awareness of public health recommendations. ■

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Contributors

C. Kenyon conceptualized the study, contributed to the analysis, and led the writing. E. Banerjee contributed to the analysis and the writing. K. Sweet contributed to the generalized estimating equations analysis design. C. Miller contributed to the writing. K. Ehresmann contributed to the writing, oversaw the project, and wrote the original grant for the project.

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Human Participant Protection

The data collected on human subjects were through routine surveillance of pertussis disease. Pertussis is a reportable disease by Minnesota disease reporting rules. Therefore, the Minnesota Department of Health Institutional Review Board deemed this activity to be nonresearch.

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