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ORIGINAL ARTICLE

Hospitalization for Ambulatory-care-sensitive Conditions in Taiwan Following the SARS Outbreak: A Population-based Interrupted Time Series Study

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Background/Purpose: In 2003, the severe acute respiratory syndrome (SARS) outbreak resulted in 8096 probable cases and 774 deaths in 26 countries. The purpose of this study was to explore the effect of the SARS outbreak on hospitalization for chronic ambulatory-care-sensitive conditions (ACSCs) in Taiwan.
Methods: We applied a population-based interrupted time series study design and used the time series auto-regressive integrated moving-average model to compare the actual and predicted admission rates of seven selected chronic ACSCs. The analyses were based on National Health Insurance hospital inpatient claims data from 1997 to 2003.
Results: The impact of SARS on ACSCs after the outbreak varied among seven selected chronic conditions. Hospitalization for respiratory conditions was significantly lower than the predicted values, whereas hospitalization for diabetes was significantly higher than the predicted values after the outbreak.
Conclusion: Admission rates for most ACSCs, except for diabetes, did not change in the post-SARS period. The reductions in outpatient utilization during the SARS outbreak did not appear to affect adversely admissions for most ACSCs. [*J Formos Med Assoc* 2009;108(5):386–394]

Key Words: ambulatory care, civil defense, health services accessibility, national health programs, severe acute respiratory syndrome

Timely and appropriate ambulatory care can prevent complications or exacerbations of diseases and reduce preventable hospitalization.[1–3] In 2003, the severe acute respiratory syndrome (SARS) outbreak resulted in 8096 probable cases and 774 deaths in 26 countries.[4] The impact of the SARS epidemic, however, was not limited to people who were infected.[5] SARS reduced considerably access to medical care and health service utilization during the outbreak.[5–13] The effects of this reduced utilization on the population's health has been studied rarely.

Taiwan was confirmed to have 346 probable cases and 37 deaths caused by SARS, and was one of the countries affected significantly by the outbreak.[4] Due to the fear of SARS, many patients and care providers were reluctant to seek or provide care. As a result, the level of health services utilization for outpatients,[5,6] inpatients,[5,6] hospices,[7] and emergency care,[8–10] decreased significantly

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Received: April 27, 2008
Revised: September 23, 2008
Accepted: December 2, 2008

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during the SARS outbreak in Taiwan. Among the different types of health care, inpatient care had the greatest reduction (35.2%) in utilization, followed by ambulatory care (16.7%). Similar trends were also observed in the greater Toronto area[11,12] and Hong Kong.[13,14] Within ambulatory care, the reduction in utilization was greatest for minor acute diseases and modest for chronic conditions.[6,15] Health service utilization for life-threatening diseases was nearly unaffected.[10,15]

Although a SARS outbreak has not recurred, other potential infectious diseases such as pandemic influenza or avian flu may emerge in the future. To guide preparation and planning, it is necessary to investigate the potential health impact of decreased service utilization caused by disruption to the health care system during major outbreaks. Ambulatory-care-sensitive conditions (ACSCs) are those for which timely and adequate outpatient care can prevent future hospitalization.[3] These conditions have been used widely to measure access to and performance of primary care, and can be used to identify areas for improving access and quality in health care delivery.[1–3,16,17] Therefore, in this study, we used these conditions as indicators to examine whether the decreased access to primary health care caused by SARS, which has been reported in previous studies,[5,6,15] had an impact on population health, as measured by hospitalization for chronic ACSCs.

The specific aim of this study was to explore the effect of the SARS outbreak on hospitalization for chronic ACSCs after the SARS outbreak. The following reasons provided explanations on why we excluded acute hospitalization for ACSCs: 1. Health services utilizations of acute conditions were not significantly affected by SARS during the outbreak.[10,11] 2. Acute conditions, in general, are more life-threatening. Hospitalization related to inappropriate primary care might have occurred immediately following the event, and not a few months later. 3. Patients with chronic conditions, particularly the less severe ones, are more likely to delay ambulatory care during the SARS outbreak.[6,15] Therefore, we only included chronic conditions in this study. The study finding might be of interest particularly to health policy makers and those in health services that are responsible for the preparation and planning for a major outbreak of infectious disease.

Methods

Study design

This was an exploratory study. We applied a population-based interrupted time series design to compare the actual with predicted hospitalization for ACSCs after the SARS outbreak, to identify conditions with increased hospitalization that might have been caused by untimely or inappropriate primary care during the SARS outbreak. The National Health Insurance (NHI) claims data during 1997–2002 were used to estimate the trends in hospitalization for ACSCs before the SARS outbreak, and to generate the predicted value in 2003. The interrupted time series design allowed us to take into account any underlying trends or seasonal influences prior to the SARS outbreak, and then quantify accurately the subsequent impact of SARS. Any changes in the trends that occurred after the outbreak were assumed to have been caused by the outbreak. Monthly admission rates for each ACSC were calculated throughout the study period based on the claims data from January 1997 to December 2003. To provide a reference, we included a non-ACSC condition, appendicitis, in this study as a comparison. Besides, because of our inability to obtain databases that link individual inpatient and outpatient data, we provided the aggregate statistics of outpatient utilization of ACSCs for reference.

Data source

The data source for this study was the "Inpatient expenditures by admissions (DD)" and "Systematic sampling data of outpatient (SCD)" datasets provided by the Bureau of the NHI, Department of Health, and managed by National Health Research Institutes. The DD dataset included each inpatient claim of every NHI beneficiary in Taiwan from 1997 to 2003; whereas, the SCD dataset included

0.2% systematic samples of all outpatient claims during the same period. NHI is a universal health insurance program, which covers about 99% of the population. Therefore, almost all hospital admissions are recorded in the NHI claims database. We used encrypted beneficiaries' identification (ID) number and encrypted hospitals' ID number to link the data and to ensure that each claim only appeared once in the analyses.

SARS periods

Since the first SARS case was identified on March 14, 2003 in Taiwan, the epidemic increased at the end of April, and reached its peak in May and June of 2003.[18] Taiwan was removed finally from the list of SARS-affected countries by the World Health Organization (WHO) on July 5, 2003. Therefore, we defined April–June 2003 as the SARS outbreak period and January–March 2003 as the pre-SARS period. We then defined two post-SARS periods: the first 3 months after the outbreak (July–September) was post-SARS-1 period, and the following 3 months (October–December) was the post-SARS-2 period.

Hospitalization for ACSCs measurement

Hospitalization for ACSCs has been used widely as a marker of access and quality of care.[1–3,16,17] The Agency for Healthcare Research and Quality (AHRQ) has defined a list of 16 ACSCs.[3] Ten of these are chronic conditions, including uncontrolled diabetes without complications, diabetes short-term complications, diabetes long-term complications, diabetes-related lower-extremity amputation, pediatric asthma, adult asthma, hypertension, chronic obstructive pulmonary disease (COPD), angina without procedure, and congestive heart failure. One is birth outcome (low birth weight) and five are acute conditions (bacterial pneumonia, dehydration, urinary tract infection, perforated appendix, and pediatric gastroenteritis).

We only included chronic conditions as indicators in this study because they were more likely to be affected by SARS than acute conditions. However, among the 10 chronic conditions, we also excluded long-term diabetes complications and lower-extremity amputation among diabetic patients because the incidence of these conditions is low, and a longer study period would have been required to observe these outcomes. Furthermore, the AHRQ guidelines for ACSCs states that the indicator for uncontrolled diabetes is designed to be combined with diabetes short-term complications.[3] Accordingly, for diabetes, we only included a combined diabetes measure that comprised uncontrolled diabetes without complications and diabetes short-term complications. As a result, we included seven ACSCs in this study. All the indicators were identified by the principal diagnoses listed on the AHRQ PQIs version 2.1, revision 4 and coded by the International Classification on Diseases, ninth revision, Clinical Modification (ICD-9-CM).

Statistical analyses

First, we used the monthly hospitalization rates for each condition between January 1997 and December 2002 to fit the time series auto-regressive integrated moving-average (ARIMA) model.[19] ARIMA models are fitted to time series data to better understand the underlying trends in the data and to predict data points in the future. The Ljung-Box Q-statistic was used to check whether lack-of-fit existed in these models.[20] Predicted monthly hospitalization rates for each selected condition in 2003 were obtained subsequently from the ARIMA models. We then compared the actual monthly hospitalization rates and the predicted rates with the 95% CI. We considered the differences between the actual and predicted monthly rate as significant if the actual hospitalization rate of a given condition was beyond the 95% CI of the predicted rate. All analyses were performed using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA) for Windows.

Results

A total of 120,330 hospitalizations were observed for the seven selected ACSCs during four time

Table 1. Number of hospitalization and outpatient visits among selected chronic ambulatory-care-sensitive conditions (ACSCs) and non-ACSCs

Conditions	pre-SARS [Jan–Mar]		SARS [Apr–Jun]		Post-SARS-1 [Jul–Sep]		Post-SARS-2 [Oct–Dec]	
	Number	Change*	Number	Change*	Number	Change*	Number	Change*
ACSC admission								
Adult asthma	7452	5.48%	3939	–36.59%	3465	–39.73%	4561	–19.88%
Pediatric asthma	1815	1.11%	822	–55.57%	869	–47.33%	1831	–14.68%
COPD	15,180	6.47%	8759	–28.94%	8115	–28.33%	10,288	–6.61%
CHF	7462	1.65%	4816	–18.48%	5303	–1.27%	6171	0.19%
Hypertension	2708	–10.00%	1814	–36.93%	2373	–15.37%	3009	10.54%
Angina without procedure	3161	–3.10%	2344	–36.20%	3230	–11.09%	3252	–7.17%
Diabetes	1955	–0.76%	1575	–4.02%	1860	11.64%	2201	26.28%
Non-ACSC admission								
Appendicitis	5589	–6.32%	5697	–16.07%	6173	–5.41%	5535	–6.14%
Outpatient visit†								
Adult asthma	277.0	3.55%	206.5	–13.78%	210.0	–3.67%	259.0	4.65%
Pediatric asthma	173.5	16.84%	106.5	–14.80%	100.5	–23.86%	180.0	9.09%
COPD	457.5	–4.19%	363.5	–12.41%	320.0	–11.23%	381.5	–4.63%
CHF	74.5	–3.87%	67.0	–16.77%	67.0	–10.67%	77.0	9.22%
Hypertension	2269.5	5.98%	1953.0	–11.41%	2072.0	–5.11%	2386.5	7.02%
Angina without procedure	382.0	–5.68%	351.5	–11.46%	392.0	–7.33%	461.5	8.72%
Diabetes	1408.5	9.70%	1245.0	–12.48%	1362.5	–7.75%	1416.5	3.62%

**Compared with the numbers during the same 3-month period in 2002; †unit: 1000 outpatient visits. COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure.*

periods (pre-SARS, SARS, post-SARS-1 and post-SARS-2) in 2003. Table 1 displays the actual number of hospitalizations for each selected ACSC and appendicitis, as well as the percentage changes in the number of hospitalizations from 2002 to 2003. Among the seven ACSCs, COPD had the most hospital admissions, with approximately 42,000 patients. All the hospitalizations for selected ACSCs were reduced in the SARS period compared with those in 2002, most notably among circulatory and respiratory conditions. The hospitalizations for most conditions were still reduced in the post-SARS-1 period, with the exception of diabetes and hypertension, which increased more than 10%, when compared with the numbers in 2002, during the post-SARS-2 period. For appendicitis, the admission numbers had stable reductions in pre- and post-SARS periods. As well as ACSCs, the number of appendicitis admissions decreased substantially in the SARS period. Table 1 also presents the number of outpatient visits for each selected ACSC, and the patterns for outpatient visits were similar to those for ACSC admissions in the SARS period. However, for diabetes, the reduction in outpatient visits was much more than the reduction in the admissions.

Table 2 presents the predicted hospitalization rates, the associated 95% CI obtained from the ARIMA model, and the differences between the actual and predicted hospitalization rates among the four periods. During the pre-SARS period, admission rates for all conditions did not differ significantly from their predictive values. However, during the SARS period, admission rates for pediatric asthma, COPD, and angina without procedure were reduced by 5.28, 7.47, and 2.50 per 100,000 population per month, and were significantly ($p < 0.05$) different from their respective predictive values. In general, the actual hospitalization

Table 2. Time series analyses of hospitalization rate for selected chronic ambulatory-care-sensitive conditions (ACSCs) and non-ACSCs per 100,000 persons

Conditions	Pre-SARS [Jan–Mar]			SARS [Apr–Jun]			Post-SARS-1 [Jul–Sep]			Post-SARS-2 [Oct–Dec]		
	Observed	Predicted*	(95% CI)	Observed	Predicted*	(95% CI)	Observed	Predicted*	(95% CI)	Observed	Predicted*	(95% CI)
ACSC admission												
Adult asthma												
Rate	14.56	13.05	(9.18–16.92)	7.65	12.65	(7.54–17.77)	6.71	12.24	(7.00–17.49)	8.72	12.19	(6.92–17.46)
Difference†		1.51	(−2.36–5.38)		−5.01	(−10.12–0.10)		−5.53‡	(−10.78–−0.29)		−3.47	(−8.74–1.80)
Pediatric asthma												
Rate	10.87	11.56	(8.21–14.91)	4.99	10.27	(6.95–13.59)	5.27	9.95	(6.63–13.27)	11.20	15.79	(12.47–19.12)
Difference†		−0.7	(−4.04–2.65)		−5.28‡	(−8.60–−1.96)		−4.68‡	(−8.00–−1.35)		−4.59	(−7.92–−1.27)
COPD												
Rate	29.46	28.28	(22.23–34.33)	16.90	24.38	(17.81–30.94)	15.56	22.27	(15.71–28.84)	19.45	21.67	(15.11–28.24)
Difference†		1.18	(−4.87–7.23)		−7.47‡	(−14.04–−0.91)		−6.71‡	(−13.28–−0.15)		−2.23	(−8.79–4.34)
CHF												
Rate	14.48	13.79	(12.10–15.49)	9.33	11.65	(9.88–13.43)	10.22	10.77	(8.99–12.55)	11.79	11.91	(10.13–13.69)
Difference†		0.68	(−1.01–2.38)		−2.32	(−4.10–−0.55)		−0.55	(−2.33–1.23)		−0.12	(−1.90–1.66)
Hypertension												
Rate	5.28	5.00	(3.50–6.50)	3.52	5.14	(2.92–7.36)	4.60	4.99	(2.19–7.79)	5.75	4.84	(1.53–8.16)
Difference†		0.28	(−1.23–1.78)		−1.62	(−3.84–0.60)		−0.39	(−3.19–2.41)		0.91	(−2.41–4.22)
Angina												
Rate	6.17	6.50	(5.68–7.33)	4.55	7.05	(6.12–7.98)	6.28	7.06	(6.02–8.11)	6.27	7.00	(5.85–8.15)
Difference†		−0.34	(−1.16–0.49)		−2.50‡	(−3.43–−1.57)		−0.79	(−1.83–0.26)		−0.73	(−1.88–0.42)
Diabetes												
Rate	2.89	2.95	(2.54–3.36)	2.33	2.57	(2.13–3.00)	2.75	2.62	(2.19–3.06)	3.25	2.73	(2.30–3.17)
Difference†		−0.06	(−0.46–0.35)		−0.24	(−0.67–0.20)		0.13	(−0.31–0.56)		0.52‡	(0.08–0.95)
Non-ACSC admission												
Appendicitis												
Rate	8.27	8.35	(7.29–9.41)	8.42	9.69	(8.10–11.28)	9.12	9.55	(7.51–11.59)	8.17	8.40	(5.95–10.84)
Difference†		−0.08	(−1.14–0.97)		−1.27	(−2.86–0.32)		−0.44	(−2.47–1.60)		−0.23	(−2.68–2.21)

**Predicted value and the 95% CI were obtained from the time series ARIMA model; †difference was calculated by comparing the actual rates with predicted values; ‡$p<0.05$. COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure.*

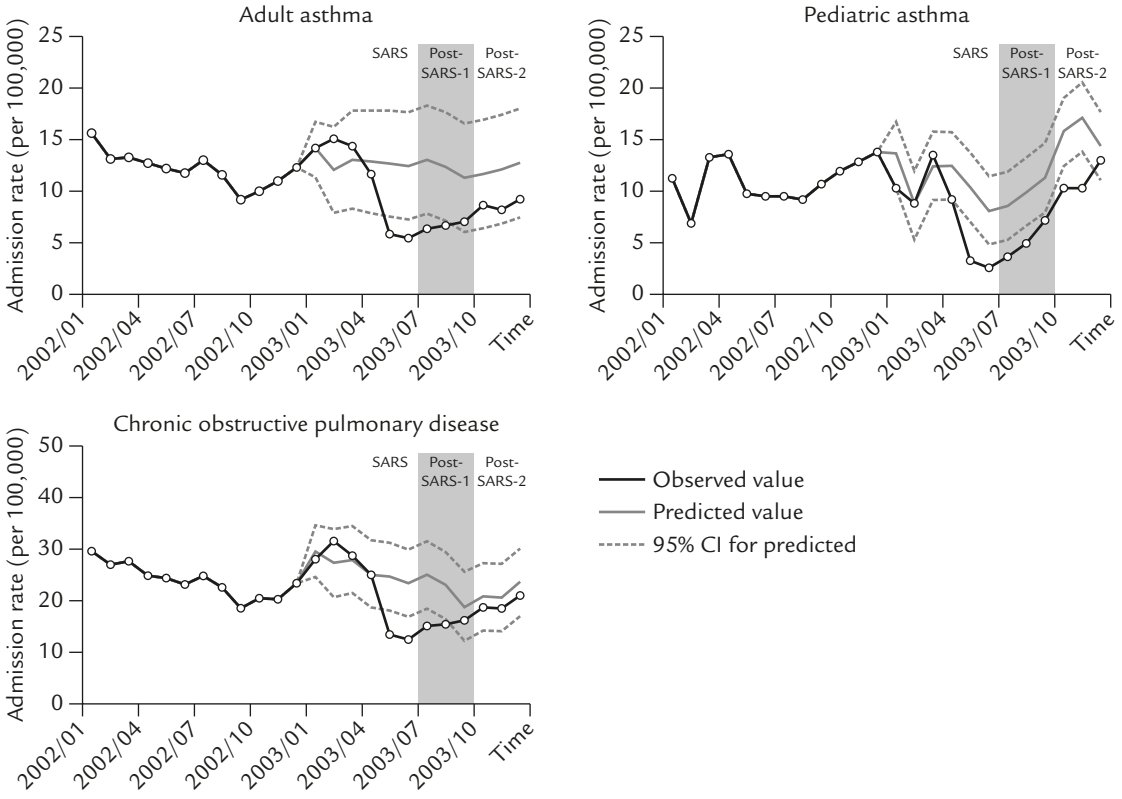

Figure 1. Hospitalization rates for respiratory conditions, January 2002 to December 2003.

rates for respiratory and circulatory conditions were lower than the predicted rates in the post-SARS periods. The admission rates for all respiratory conditions were lower compared with their predictive values in the post-SARS periods; however, the differences were significant only in the post-SARS-1 period. Yet they were higher than the predicted rates for hypertension (during post-SARS-2) and diabetic conditions. The diabetes admission rates increased by 0.52 per 100,000 population per month, which was significant ($p < 0.05$) in the post-SARS-2 period. Compared with the ACSCs, the admission rate for appendicitis remained insignificant during all study periods.

Figures 1–3 display the monthly trends in hospitalization rates for the seven selected ACSCs, with predicted values and 95% CI indicated for 2002 and 2003. During the SARS period, the actual hospitalization rates for all selected ACSCs were significantly lower than the lower boundary of the 95% CI of the predicted rates for at least 1 month, except for diabetes. The differences in hospitalization rates for respiratory conditions during the post-SARS-1 period, shown in Figure 1, were also significant for at least 1 month. Yet, only the differences in pediatric asthma remained significant in two of the three months during the post-SARS-2 period.

In Figure 2, the actual hospitalization rates for the three circulatory conditions all fell within the range of the 95% CI of their predicted values in both post-SARS periods. Figure 3 shows that the actual admission rates for diabetes also fell within the 95% CI during both post-SARS periods. Nonetheless, the actual admission rates for diabetes were significantly higher than the predicted rates and exceeded the upper limit of the 95% CI at the end of 2003.

Discussion

We found that the actual hospitalization rates for six selected ACSCs, particularly respiratory conditions, were significantly lower than their predicted rates for at least 1 month during the

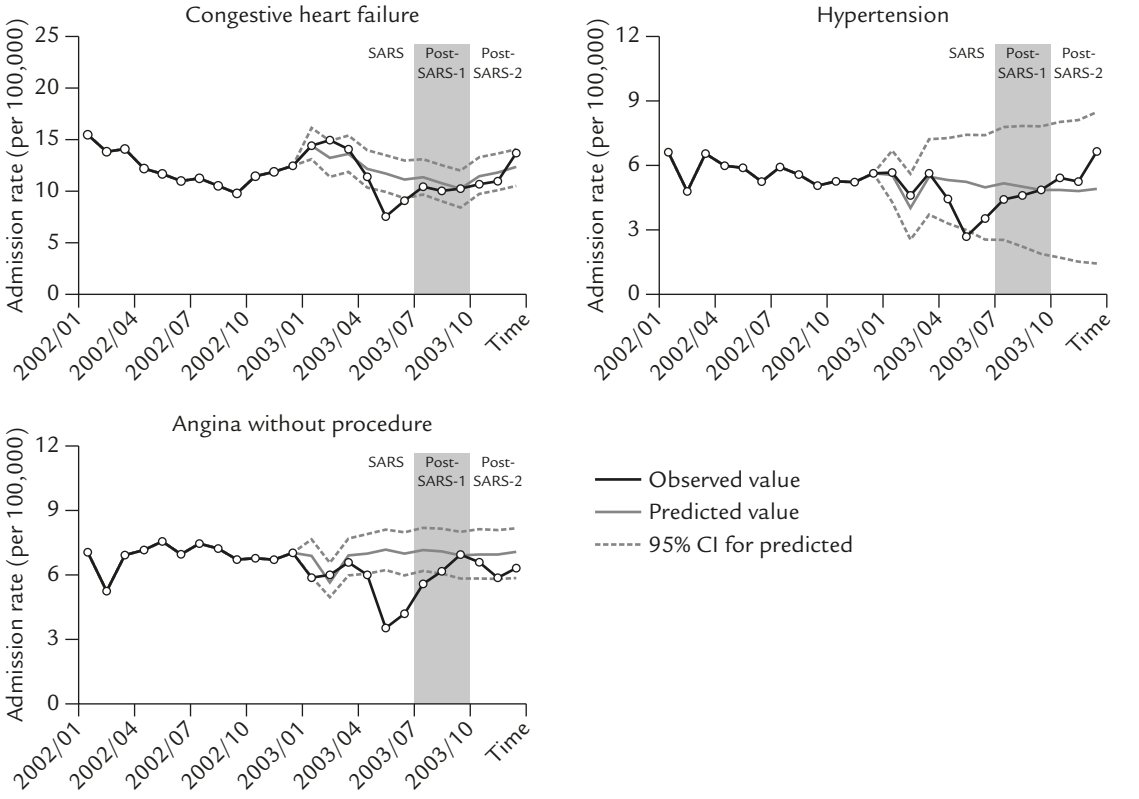

Figure 2. Hospitalization rates for circulatory conditions, January 2002 to December 2003.

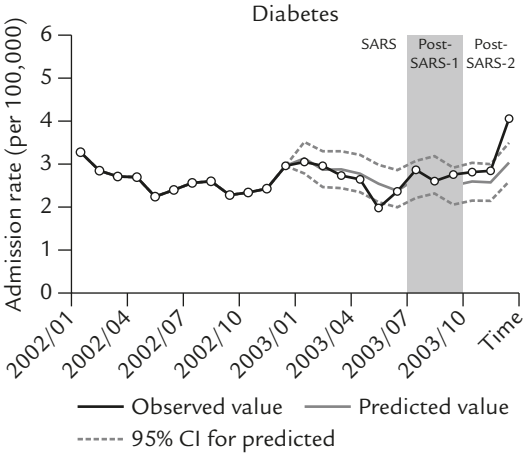

Figure 3. Hospitalization rates for diabetic conditions, January 2002 to December 2003.

SARS period. This trend remained significant only in respiratory conditions during the post-SARS-1 period. The admission rates for two conditions, hypertension and diabetes, were higher than the predicted rates during either of the post-SARS periods, but the differences were significant only for diabetes in the post-SARS-2 period. In contrast, no significant change in admission rates for the reference condition appendicitis was observed during the entire study period.

The reduction in hospitalization rate was most profound among respiratory conditions and was consistent with previous findings during the SARS period.[6] These trends continued to be significant in the post-SARS-1 period. Since SARS is associated with the respiratory system, people with respiratory conditions were more likely to avoid hospital contact compared with people with other conditions.[6] The Health Belief Model[21] can be used to explain such behavior, when people may have evaluated the perceived susceptibility and benefit before taking a health-related action. In addition, people were more cautious about their health during the SARS outbreak and took all means available to prevent respiratory infection (e.g. wearing masks and avoiding public gatherings).[22] Another explanation is that the WHO warning about the return of SARS may have provided a booster effect during the post-SARS-1 period and even in the post-SARS-2 period.[23]

Our study indicated that the actual admission rates for diabetes were significantly higher than the predicted values during the post-SARS-2 period. Diabetic patients might have worse access to care because several hospitals discontinued their emergency and routine services, or mailed the medications to patients during the SARS outbreak.[24,25] Since medication alone is not sufficient for diabetes, it is possible that some difference between actual and predicted admission rates for diabetes during the post-SARS-2 period resulted from under-use of regular or effective care during the SARS outbreak. We found that outpatient utilization reduced by 12.48% in SARS period. If we take the increased trend for diabetes in the pre-SARS period into consideration, the actual reduction was as high as 19.42%, and was ranked the second among all the ACSCs in our study. This might support partially our above explanation and explains why the admission rates for other ACSCs were not elevated significantly after the SARS outbreak. However, we were unable to examine the relationship between outpatient and inpatient utilization directly, to provide further evidence, because the NHI outpatient database provided by NHRI is sampled based on outpatient visits rather than individuals; thus, we were unable to obtain meaningful individual samples in the present study.

Previous studies have shown that hospitalization rates declined during the SARS period in Taiwan,[5,6] and have found no significant changes in mortality, readmission, and complication rates for critically ill patients in Toronto.[26,27] However, the present study is possibly the first to explore the possible impact of SARS on hospital admissions in the post-SARS period in Taiwan, by focusing on specific conditions such as ACSCs. In addition, the application of the population-based interrupted time series design, using a non-ACSC condition for comparison, did allow us to take into account the underlying trends and seasonal effect of the admission rates, and rule out other possible contemporary influences present during the study period. Besides, the Ljung-Box Q-statistic enabled us to select the best-fitting ARIMA models, which was indicated by the fact that most of the actual values in the pre-SARS periods were within the 95% CI of the predicted values.

This study however has some limitations that warrant discussion. First, we did not compare the changes in ACSC admissions among areas with different impacts of SARS. This was because almost every area in Taiwan was in a state of alert during the SARS outbreak, and many hospitals suspended emergency, outpatient, inpatient or all services during that time, even hospitals in areas without any probable SARS cases, such as greater Chiayi area, Taitung and Yilan Counties. Second, we were unable to evaluate the impact of SARS after 2003 because NHI introduced many interventions in 2004, including: reduction of outpatient and increase of inpatient budgets; implementation of hospital self-management/Hospital Center of Excellence Initiative; revision on NHI fee schedules; and the launch of family physicians initiatives. It would be inappropriate to relate the changes between the post-SARS period and 2004 to the impact of SARS. Besides, the accuracy of the predictions from the time-series model would be greatly reduced for a longer period. Third, we did not conduct a simple correlation analysis between aggregate outpatient and inpatient statistics, because the health seeking behavior might have varied among conditions with different severity and likelihood of acquiring SARS at health facilities (e.g. patients with respiratory diseases were more likely than others to acquire SARS).

In conclusion, we found that the impact of SARS on hospital admission rates after the SARS outbreak varied among different conditions. It had a negative and significant impact on respiratory conditions in the first post-SARS period, no significant impact on circulatory conditions, and a positive impact on diabetes conditions during the second post-SARS period. In addition, the admission rates for most ACSCs, except for diabetes, did not change in the post-SARS period. The reductions in outpatient utilization during the SARS outbreak did not appear to affect adversely admissions for most ACSCs.

Acknowledgments

We thank the NHRI in Taiwan for providing the data. However, the authors take full responsibility for the article. This study was self-funded, and none of the authors have any conflict of interest in connection with this manuscript.

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