Infection Control Studies

Cholera in Ecuador—Current relevance of past lessons learnt

Malavade SS.[1], Narvaez A.[2], Mitra A.[3], Ochoa T.[1], Naik E.[1,5], Sharma M.[5], Galwankar S.[1], Breglia MD.[5], Izurieta R.[1,4]

[1]Department of Global Health, University of South Florida, [2]Ministry of Public Health of Ecuador, [3]Department of Community Health Sciences, University of Southern Mississippi, [4]Biomedicine Center, Universidad Central Ecuador, [5]University of South Florida College of Medicine, Florida, USA

Address for correspondence:
Dr. Ricardo Izurieta,
Department of Global Health,
College of Public Health, University of South Florida,
13201 Bruce B. 4281 Downs Blvd., MDC56 Tampa, USA.
E-mail: rizuriet@health.usf.edu

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ABSTRACT

This report analyses the trends in the cholera epidemic that hit Ecuador in 1991. The study is based on personal experiences and analysis of epidemiological databases from the Ministry of Public Health of Ecuador. The number of cases and initial attack rates in an immunologically naïve population are described by province. An analysis of the Andean and coastal cholera patterns of transmission are described along with its associated risk factors. The logistical, environmental, and socio-cultural risk factors prevalent during the epidemic and the control measures implemented are also reviewed. Also, the role of the epidemic in the development of the public health and healthcare resources in Ecuador is discussed here. Current data indicate favorable conditions for another outbreak of cholera in Ecuador. In view of the existing risk factors, new strategies are proposed to prevent such an epidemic in the future.

Key words: Cholera, epidemic, epidemiology, Ecuador

INTRODUCTION

Cholera is a virulent infectious disease characterised by gastroenteritis and caused by ingestion of enterotoxin-producing strains of the bacterium *Vibrio cholerae*. Clinical presentation of cholera ranges from asymptomatic to severe diarrhoea, vomiting and dehydration. Although cholera has an incubation period of 1-2 days, symptoms may develop quickly as it has been reported to kill healthy adults within a few hours. Mortality among the untreated ranges from 50% to 75%. Cholera is spread via faecal-oral transmission, mainly through contaminated food or water. The mainstay of treatment is rehydration therapy.

Initial reservoir of cholera was the *Ganges* delta in India and was responsible for repeated pandemics that affected Asia, Africa, and the Americas. It remains endemic in many regions of the world and has been responsible for countless epidemics with millions of fatalities over the past 3 centuries. The current, i.e. seventh, pandemic, originated in South Asia in the 1960s and later spread to Africa and most recently to the Americas in 1991. Cholera was first reported in the beginning of 1991 near Lima, Peru. Many theories exist as to how the bacteria was introduced, including possible contamination of bilge water in a Chinese freighter and contaminated zooplankton in the setting of unusually warm weather. Disease spread rapidly throughout many South and Central American countries likely secondary to vulnerable populations, poor water supply, and overcrowding.

Cholera in Ecuador

The first case of cholera was reported in Ecuador on February 28, 1991, a few weeks after Peru declared a cholera epidemic. It has been reported that an Ecuadorian fisherman traveled to Peru and was exposed to cholera. Upon his return to the town of Bajoalto, El Oro province in Ecuador, the disease spread rapidly leading to an epidemic. In the first epidemiological week, cases were reported in widespread regions of the country, like Esmeraldas in the North, Guayas in the centre of the coastal zone, and across the Andean highlands. Within months, the epidemic had reached beyond the Andean mountains to the Amazon River, and spread throughout the rainforest. At the peak of the epidemic, the 17th epidemiological week (April 27-May 04, 1991), more than 3,000 new cases were reported in the country.[1] The extent of the problem is summarised in Table 1.

Strategies Planned and Implemented

The disease spread rapidly with high mortality rates since South America was a virgin territory with cholera naïve population. Figure 1 presents the methods implemented to control and prevent the spread of cholera.

In most instances, the base of the prevention pyramid is the primary response in emergency situations. However, in view of the high risk of morbidity and mortality, it was necessary to implement a comprehensive and simultaneous prevention strategy incorporating all methods as given

in Figure 1 to control the epidemic. Accordingly, the first step was to implement the secondary level of prevention, concentrating on early diagnosis and early treatment of affected patients. Another factor contributing to the clinical response was that disease spread was distributed over a longer period of time. This allowed for better utilisation of the limited healthcare infrastructure and gave adequate time to healthcare providers to respond and deliver better quality of care. This allowed for the education and training of healthcare providers in the prevention and management of cholera.

Patterns of cholera transmission in Ecuador

John Snow demonstrated that throughout the 1856 epidemic of cholera in London, the source of infection was a contaminated municipal water supply pump.[2] Therefore, water sources in the affected regions of Ecuador were examined to rule out a source of contamination. This was accomplished by monitoring for the presence of any pathogenic organisms and also for the level of residual chlorine that was released to the community in distribution pipes. Investigations revealed that the water sources and water treatment plants were not contaminated. However, the water that the population received from the supply was indeed contaminated with *V. cholerae*. A physical trace of supply pipelines uncovered many clandestine water connections that were illegally rigged in low-income regions. Compromise in the integrity of the supply system was responsible for contamination due to frequent fall in the water pressure and other problems in the distribution system.[3]

Another instance of water contamination was documented in a small city located downstream from a regional hospital. It was reported that an increase in the number of cholera infections was noted in the hospital that disposed treated sewage directly into the river. Further investigation revealed that the hospital staff was using sodium hypochlorite solution to treat the sewage waste water prior to disposal into the river. Unfortunately, this actually resulted in an enhancement of the sewage water as a culture medium for the growth and proliferation of *Vibrios*. This contaminated the source of drinking water for people residing in the regions downstream. This event brought to fore the need for proper instructions to field personnel and timely follow-up to ensure that such unanticipated events do not undermine other infection control measures. It was then recommended, and demonstrated, to all sanitation units to treat the sewage with hydrochloric acid prior to disposal. A periodic follow-up was then completed to ensure that the proper protocol was being followed to prevent any future mishaps.

A major intervention strategy focused on decontamination of the water supply. Public Service Announcements (PSAs) advised the community to boil water prior to consumption. However, the availability of fuel was a major impediment towards achieving this goal in many areas. This led to evaluation of alternative decontamination measures. One alternative measure that was successfully implemented was the addition of sodium hypochlorite to the water stores. This effectively eliminated

the organism from water stores.[4] The distribution of sodium hypochlorite was cost-effective, socially acceptable and easy to implement. Issues related to the use of sodium hypochlorite included monitoring the quantity used to treat stored water and the diameter of the opening of water containers. It was observed that water stored and treated in narrow-mouthed containers was better in terms of effective disinfection as compared to wide-mouthed containers. Therefore, it was recommended to treat water with sodium hypochlorite prior to drinking and to use narrow mouthed containers to store drinking water.

Increased infection rates were also observed in families that directly dipped drinking vessels into the stored water. Therefore, it was recommended that the containers should have taps to dispense water. Also, the use of soap with hand washing was associated with a lower incidence of cholera. This observation led to the recommendation of washing hands with soap prior to and after eating, drinking, and especially bathing.

When outbreaks of such a large scale occur, it is imperative to look for all possible sources of disease transmission. Waterborne transmission was not the only method of transmission observed during this epidemic. Although waterborne transmission was the major mechanism for transmission in the Andean highlands, consumption of seafood was a major contributor in the coastal regions.

The consumption of contaminated food was a major contributor to cholera spread during this epidemic. In particular, consumption of raw seafood has been associated with increased risk of cholera infection in South America.[3,5-7] For example, in the US, a small outbreak of cholera occurred from consuming crab meat brought back in a suitcase of a traveler from Ecuador.[8] In the coastal regions of Ecuador, “ceviche” is a popular local seafood meal that comprises raw seafood consumed after preparation with lemon juice. *V. cholerae* was found in estuarine environments along with the resident plankton and crustaceans including shrimp and crab. Ceviche prepared from animals living in these environments was found to have a higher risk of causing cholera infection if consumed raw or without adequate preparation with lemon juice. Adequate acidic lemon marinade was found to offer protection against the *Vibrios*, and thus act against infection.

There was a markedly increased prevalence of the disease among males and the population of age 15 years or older. This trend can be correlated to the social and behavioral tendency of males working outside of the home, and therefore consuming higher amounts of food sold at street vendors. The street markets in Ecuador are an integral part of the culture and is a traditional way of life for Ecuadorians. The markets have historically sustained an economic cash flow in the society by providing inexpensive aliments. In addition, in the last few decades, the street markets have provided increased employment opportunities in urban areas. Despite the benefits of economic growth, the street markets carry the disadvantages of microbial contaminations associated with lack of potable water, sanitary facilities, and deficient hygiene of the vendors.

In the Andean highlands, it was observed that increasing mortality was associated with a subsequent increase in cholera incidence. The local cultural customs dictated that in case of death, a body must remain in the family home for five days following death to facilitate visitation from family and friends. This resulted in increased exposure of healthy community members to infectious waste and material. Visitors would also often be served food in the home of the infected corpse. Interestingly, cholera is characterised by effortless diarrhoea and post-mortem sphincter relaxation. Therefore, it often resulted in passive expulsion of colonic contents at the time of death, which were soaked in the clothes and sheets covering the corpse. These contaminated articles were likely handled with bare hands, which further contaminated and exposed those living in the house.

A prevention strategy implemented during this epidemic was designed to address three components of contamination. These strategies involved preventing family members from coming in contact with body fluids of the dead body by using plastic body bags, hastening the burial and preventing transmission to the visitors of the dead. Recommendations included advice to the community to refrain from communal feasts observed at such occasions.

Treatment of cholera in Ecuador

The most dreaded complication from cholera infection is severe diarrhoea, leading to dehydration. Therefore, the mainstay of therapy involves efforts to restore volemia in victims. The intervention strategies in the secondary and tertiary levels of prevention were centred on the use of Oral Rehydration Therapy (ORT) and antibiotics. The prevalent standard of care at the time was the use of intravenous fluid replacement. Unfortunately, this led to an overburdening of the then existing healthcare infrastructure. Placement of intravenous lines required trained individuals, increasing the financial burden. Moreover, the time from primary referral to evaluation at an appropriate healthcare facility was often delayed and many patients actually went from mild to severe dehydration in the interim. ORT was emphasised at peripheral healthcare centres for management of diarrhoea of all severity. Therefore, the duration between referral and evaluation at a tertiary health centre was utilised to initiate rehydration therapy. This decreased the progression of dehydration and helped decrease mortality. Also, the emphasis on ORT also controlled healthcare costs.[9,10]

One component of ORT administration is Oral Rehydration Salts (ORS) often available in a packet. These packets usually contain a mixture of sodium and glucose, and distributed in the communities affected by cholera. The provision and availability of ORT packets was emphasised at all places of human congregation and community centres, increasing access and distribution of ORT packets. It was difficult to access many of the remote highlands to provide screening services, public health education and ORT packets through the regular public health channels. In such areas, commercial products like soft drink bottles were utilised as vessels for ORT packets. Every bottle of

soft drink was distributed with an ORT packet along with labeled instructions explaining the method of preparation. This strategy helped the ORT to reach inaccessible regions of the country.

In case of severe dehydration, the most efficacious treatment consisted of Intravenous Fluid (IVF) administration of Ringer's lactate. During the initial outbreak of the cholera epidemic, it was found that in-hospital preparations consisting of sodium and potassium chloride added to dextrose fluids became increasingly time-consuming, complex and risky due to possible electrolyte imbalances. Therefore, a standardised solution of Ringer's lactate was implemented for intravenous rehydration therapy. Rainforest health promoters were trained in this new strategy to encompass a larger area of care.

However, the availability of Ringer's lactate was limited; consequently, other IVFs containing glucose, sodium and potassium were used as emergency care. Finally, in the first days of the epidemic, coconut water was administered intravenously, which proved to be a successful survival strategy in some areas of the rainforest.

Outcome Measures

The main outcome measures used to monitor progress of the various control and prevention strategies of the epidemic in Ecuador were incidence of new cases and the cumulative incidence rates. Table 2 shows the number of cases and incidence rates of acute diarrhoea and cholera cases in Ecuador from 1990 to 2007. Figure 2 shows the number of cases and Figure 3 shows the incidence rate for cholera and acute diarrhoeal disease in Ecuador from 1990 to 2007.[11,12] It is seen that after the 1991 epidemic, the single spike in the number of cases was observed in 1998 and was attributed to the El Nino weather event in Ecuador.[13]

Beneficial outcomes of the cholera epidemic

The cholera epidemic had certain beneficial effects with regard to public health awareness in Ecuador. Not only did it illustrate the potential for such epidemics in the future it also helped equip the existing healthcare infrastructure to respond to future epidemics. Prior to this epidemic, local healthcare personnel had virtually no experience in managing such devastating diseases. These led to better training and provided field experience for healthcare workers in handling infections at epidemic proportions. The healthcare system developed logistical systems and procedures including intense personnel education and rigorous training, as well as establishment of regional treatment centres in the hinterland. Also, local culinary and social customs contributing to the epidemic were scrutinised. Public health education and legislation were imperative to control spread of the disease.

Figure 2 and 3

Potential existing risk factors and population susceptibility

Despite the control of epidemic and better systems in place, many risk factors previously identified and discussed above continue to exist in Ecuador and could favour a second outbreak of cholera. These factors include an ever-growing population with potential proliferation of clandestine water connections in the lower socio-economic regions of major commercial cities like Guayaquil and Quito. In addition, despite the current low prevalence rates of cholera, with a gradual increase in susceptible population and potential risk of civic complacency, which may lead to diversion of funds from healthcare programmes and cholera education, may result in poor surveillance and control measures. The regional appreciation of potential contaminated food sources, such as ceviche, remains a perpetual risk due the presence of free living *Vibrios* in coastal regions. The public memory of the diarrhoeal malady is fleeting both socially and immunologically. This could result in a resumption of high-risk behaviour like increased consumption of street food and less emphasis on hygiene by the street food vendors. Cultural customs of retaining corpses in the family home for five days may also resurface. Current data models and temporal trends of other diarrhoeal diseases in Ecuador [14] indicate an existing risk for another outbreak even if a single case were to occur.

Proposed new strategies for preventing future outbreaks, public health education and social empowerment

Establishment of makeshift treatment centres in remote areas during diarrhoeal outbreaks and early involvement and education of the community, including healthcare providers, traditional healers, religious and political leaders would be effective measures. Hygiene control, protection of water supply and sanitation maintenance are also effective strategies for the prevention of future outbreaks. Education concerning risk factor modification, recognition of severe disease and dehydration as well as introduction of ORT to the school curricula may empower children and their parents with the tools to prevent large outbreaks. Strategic stocking of healthcare supplies at regional health centres is essential for the control of diarrhoea epidemics.

Some of the targeted interventions include:

1. General community including healthcare personnel should be trained for preparation and appropriate use of ORT to prevent and treat dehydration. This should include a mandatory annual training session for all healthcare personnel for treatment and control of diarrhoeal diseases.
2. Parents should be properly educated and trained in diarrhoea management and the utilisation of ORT.
3. Healthcare providers should emphasise and promote breastfeeding, especially during and after diarrhoea.
4. In the setting of a new or recurring epidemic, vaccination therapy for mothers may be considered to protect young children as infants can receive antibodies via breast milk.[15]

CONCLUSION

The cholera epidemic in Ecuador in the early 1990's was instrumental in sensitising the public and health officials in the establishment of systems to prevent future epidemic. The experience gathered through this epidemic highlighted many socio-cultural, environmental, infrastructure and logistical issues that were successfully addressed by health authorities. However, it is concerning that the incidence of acute diarrhoeal diseases has increased successively in the last decade. This may be a harbinger of another impending epidemic. Thus, it becomes imperative to investigate the evident increase in widespread diarrhoeal illness to reinforce public health preventive measures that were successfully implemented to control the cholera epidemic of the 1990s along with the new recommendations.

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Legends

Figure 1: Strategies used for different levels of prevention

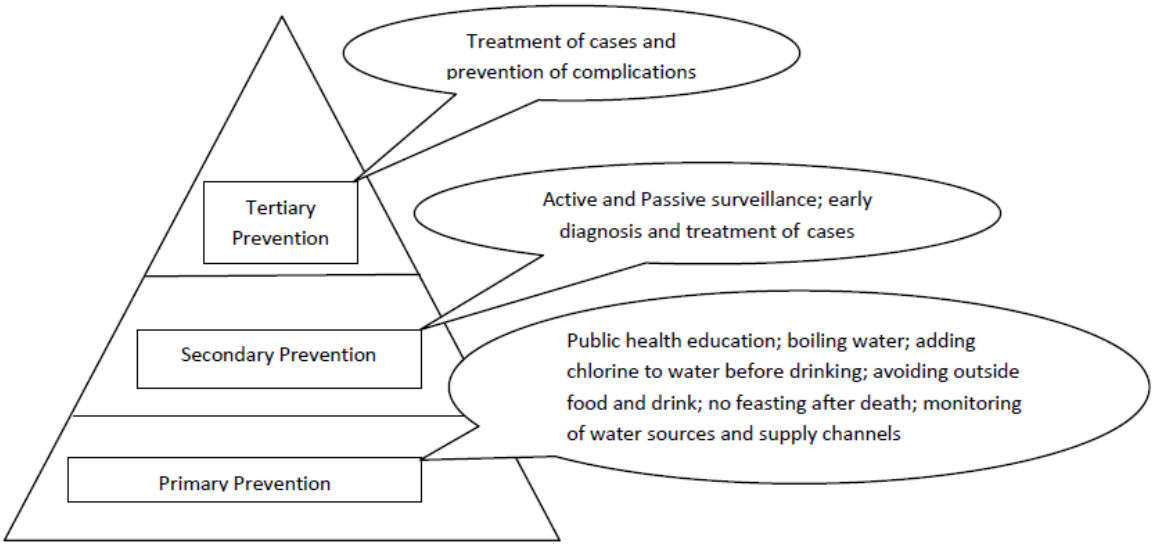

Figure 2: Annual number of cases of cholera and acute diarrheal diseases in Ecuador from 1990-2007.

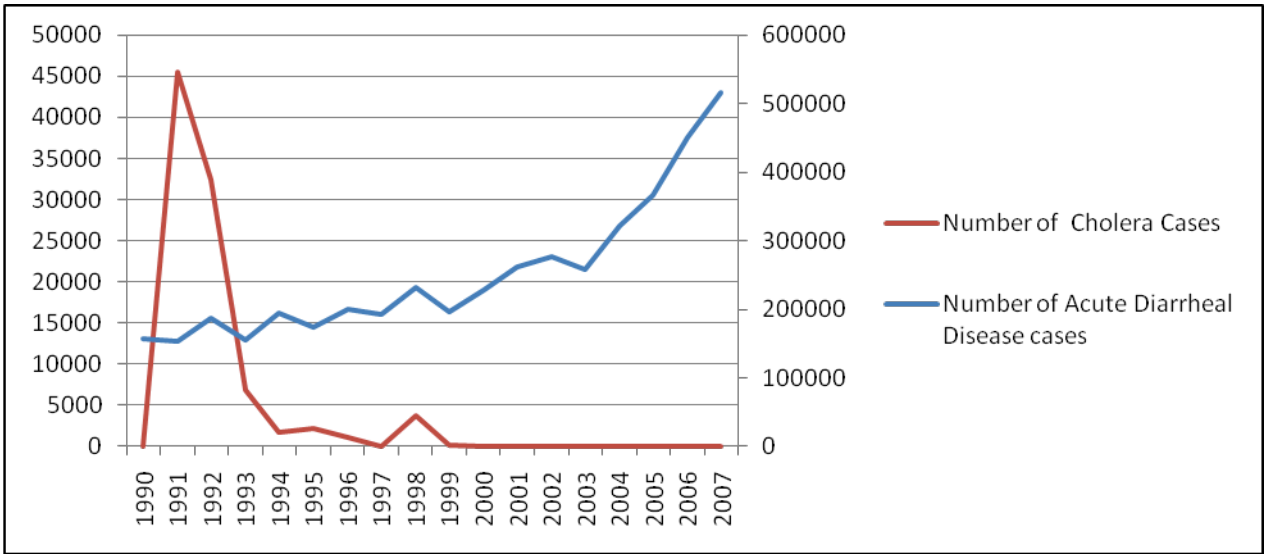

Figure 3: Annual incidence rate of cholera and acute diarrheal diseases in Ecuador from 1990-2007.

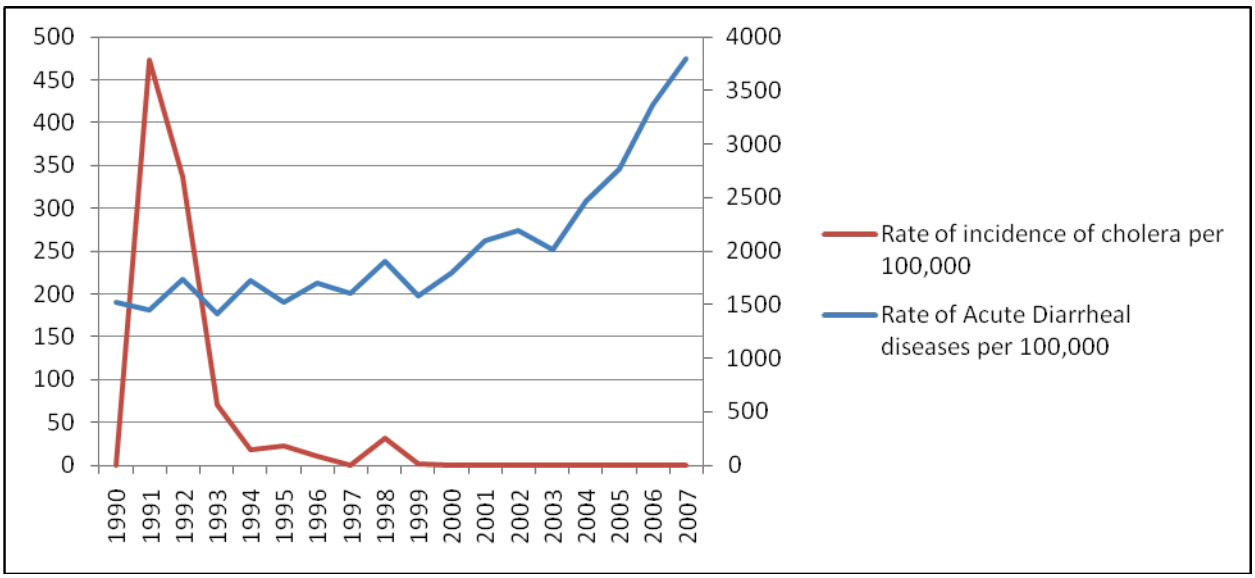

Table 1: Cholera cases and incidence rate by province and region in Ecuador, February 28-December 28, 1991

Region	Province	Cases	Attack Rate x100,000

Andean	Azuay	448	79.8
	Bolivar	81	45
	Carchi	38	24.3
	Cañar	706	337.5
	Chimborazo	3,140	774.5
	Cotopaxi	2,177	108.3
	Imbabura	4,745	1,553
	Loja	321	75.6
	Pichincha	2,127	108.3
	Tungurahua	1,732	424.2
Coastal	El Oro	4,673	1,015.4
	Esmeraldas	5,425	1,585.3
	Guayas	14,951	532.8
	Los Rios	3,814	651.2
	Manabí	1,485	161.2
Amazonian	Morona	3	2.8
	Napo	1	0.86
	Pastaza	34	71.8
	Sucumbíos	51	57.5
	Zamora	5	6.7
	Total	46,320	429.2

Table 2: **Annual number of cases and incidence rate of Acute Diarrheal Diseases and Cholera cases in Ecuador from 1990-2007**

Year	**Number of acute diarrheal disease cases**	**Number of cholera cases**	**Incidence rate of acute diarrhoeal diseases per 100,000**	**Incidence rate of incidence of cholera per 100,000**
1990	1,56,697	0	1,526.6	0
1991	1,52,447	45,542	1,451.6	473
1992	1,86,200	32,421	1,733.5	337
1993	1,55,165	6,838	1,413	71
1994	1,94,243	1,717	1,731	18
1995	1,74,472	2,184	1,522.4	23

1996	1,99,352	1,054	1,704	11
1997	1,92,012	65	1,608.5	0.54
1998	2,32,284	3,755	1,908	30.84
1999	1,96,902	171	1,577.4	1.37
2000	2,27,477	27	1,799.31	0.21
2001	2,61,884	11	2,098.44	0.09
2002	2,76,844	3	2,186.64	0.02
2003	2,58,265	34	2,011.01	0.26
2004	3,22,245	5	2,473.69	0.04
2005	3,66,324	0	2,772.01	0
2006	4,50,963	0	3,363.32	0
2007	5,16,567	0	3,796.76	0