

Full Length Research Paper

Epidemiological investigation of death cases by pesticide poisoning

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This study gives the report of an epidemiological investigation of seven death cases in a police force headquarters by pesticide poisoning diagnosed by the decrease of the enzyme choline esterase activity. A case control study with an environmental description has been realized, permitting the establishment of temporarily dynamic relationships among the death cases. In Africa, there are many incidents of domestic or professional poisoning with a fatal ending for which, few data are available. The aetiological orientations are discussed in the African context and the difficulties to reach the analysis of toxicology in sub-Saharan Africa are underlined.

Key words: Poisoning organophosphate, organochloride, Senegal.

INTRODUCTION

Between February and March 2004, 7 cases of an unexplained sickness occurred in a family living in a gendarmerie headquarters in Dakar. In this decade, cases of sickness leading to unexplained deaths have been regularly reported in Senegal without any defined aetiology found. The last occurrence was dated in November 2005, in Bignona (400 km South Dakar), with 28 deaths out of 47 cases. In June 2007 (Sy, 2003), four death cases occurred in a family in Saint-Louis (250 km North Dakar) (Lo and Diagne, 2007). An epidemiological investigation was conducted in order to describe the morbid phenomenon, to identify the causal agent and to determine the risk to the population in order to implement the measures of control.

METHODOLOGY

Description of the family and location of the incidence

The family lived in a two-room flat plus a kitchen. The head of the family was a gendarme posted at the brigade of Touba (200 km

Dakar) since October 2003. He stayed in Dakar at least once a month. The wife was unemployed. The other victims were school children. During the rainy seasons, they stay in the village for 1 or 2 months to help in the fieldwork. Considering the tight accommodation space, the next apartment was given to his 3 sons. That apartment was only used for sleeping. The meals were been prepared and served commonly in the principal apartment. Because of frequent water scarcity, cans of diverse materials were stored in the kitchen for keeping water. An artisanal hand pump located near the floor was used to supply water. Generally speaking, the level of salubrity was unsatisfactory.

Study design

A case-control study was conducted among the population living in the headquarters; a case where any person living in the headquarters, alive or dead, have presented, between January and April 2004, neurological troubles of diplopia type, visual fuzziness or troubles of consciousness. The controls were chosen in the close neighbourhood of the same building and of the same corridor as the cases according to the age and gender.

Direct and well- structured interviews were done through questionnaires to define the socio-demographic characteristics, establish the family relationships, describe the apartment and localise every member's bedroom. The clinic's file of hospitalized cases at the headquarters nursery and at the four main hospitals in Dakar, were gathered to characterise the clinic signs and the complementary examinations were made such as blood count standards, widal serology, electroencephalogram, cerebral scanner,

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cerebral radiograph and the conclusions of autopsy.

Removal of water (faucets, recipients found there), food and most of the mattresses were done. Blood sample punctures were also done on patients and control groups. On these different samples, toxicological, microbiological and serological analysis was done. The most frequent arboviroses in Senegal were looked for in the cases' blood (the Rift valley fever, Crimean Congo Hemorrhagic Fever of, Yellow Fever, Dengue 2, West Nile and Chikungunya). For that, 3 different techniques were used: i) Serology by Elisa, ii) molecular biology by RT-PCR nesting and iii) attempt of isolation by culture on new-born mouse brain (Tall et al., 2009).

RESULTS

Description of the population studied

Within the beginning of February to the end of April 2004, among the 9 members of the family residing in the headquarters, 7 have fallen ill and died (Figure 1), (sex-ratio M/F = 0.75) with an average period of incubation of 22 days (± 15) (min: 6 max: 45). The medium age (min-max) was 21 (14 - 42). For the 15 controls, the medium age (min-max) was 23 (10 - 54) with a sex-ratio M/F = 0.5. Any other similar case has not been reported in the health services, neither at the direction of statistics of the Ministry of Health.

The clinical signs include digestive signs of vomiting and stomach pains; central neurological signs of dizziness, headaches, troubles of coordination, elocution trouble; mobility trouble at the level of inferior members, sometime agitation and convulsions.

Toxicological results

The toxicological researches on the water, food and wool mattress have shown negligible quantities (< 0.03 mg/l) of thirty organochlorine pesticides or the most currently used organophosphates. The enzyme dosages showed a decrease of the enzyme choline esterase activity on the cases. The average value in international units on the cases was of 18.45 ± 16.93 ; on the controls it was of 25.73 ± 15.25 ($p < 10^{-3}$). The content of heavy metals and minerals in food and water was in the limits of normality (arsenic < 0.1 mg/kg, lead = 0.4 mg/kg; mercury = 0.01 mg/kg; cadmium = 5 mg/kg; iron = 245 mg/kg).

Microbiological results

The microbiological analysis were concluded to be an unsatisfied quality of water with: revivifying micro-organisms at 37°C in 1 ml > 300 (norms 10 - 300) revivifying micro-organisms at 22°C in 1 ml > 300 (norm 100 - 3000), negligible values < 1 of coliforms, enterocoques and spores of sulfito-reductive bacteria.

Research of arboviroses

The different techniques used for the diagnostic of the arboviroses were negative.

Biological analysis

Globally the biological results did not show any particularities. The serology of Widal done on the cases and controls blood was negative.

Other complementary analysis

The electro-encephalographic results showed brain suffering caused by confusion on the cases 5 and 6. The scanners done on the subjects 5 and 2 also showed a vascular cerebral accident at the cerebellum for subject 2 and the autopsy done on subject 2 showed hemorrhagic injuries at the mesentery.

DISCUSSION

The absence of fever and the microbiology and virology results were not favourable to an infectious aetiology, although the quality of water was unsatisfying. Poisoning by pesticide is the most probable cause considering the decrease of the activity of cholinesterastic enzyme which is an indirect sign. This diagnosis is all the more probable due to the fact that the family is from the southern part of Senegal and on the occasion of frequent journeys, food products meant for consumption (palm oil, fruit cereals etc.) were bought. In this agricultural region, which has borders with 3 countries, pesticides were often used and were kept under control. In this decade, three episodes of mysterious diseases with unexplained deaths have been reported with a total of 190 cases among which there were 65 deaths. The last one was dated in November 2005. This occurred in the department of Bignona. It stated 47 cases among which there were 28 deaths (Sy, 2003). After this episode occurred in the headquarters, 2 other girls (aged 2 and 4 respectively), who frequently visited the family at the headquarters, died after having shown the same clinical signs in the course of April 2004.

The diagnosis of pesticides requires a technical plateau often unavailable in sub-Saharan Africa. Also, the probable aetiologies in an African context have been discussed.

Botulinum toxin

Considering symptoms such as diplopia, visual disturbances, hypomotricity could be favourable elements (Faure, 2009).

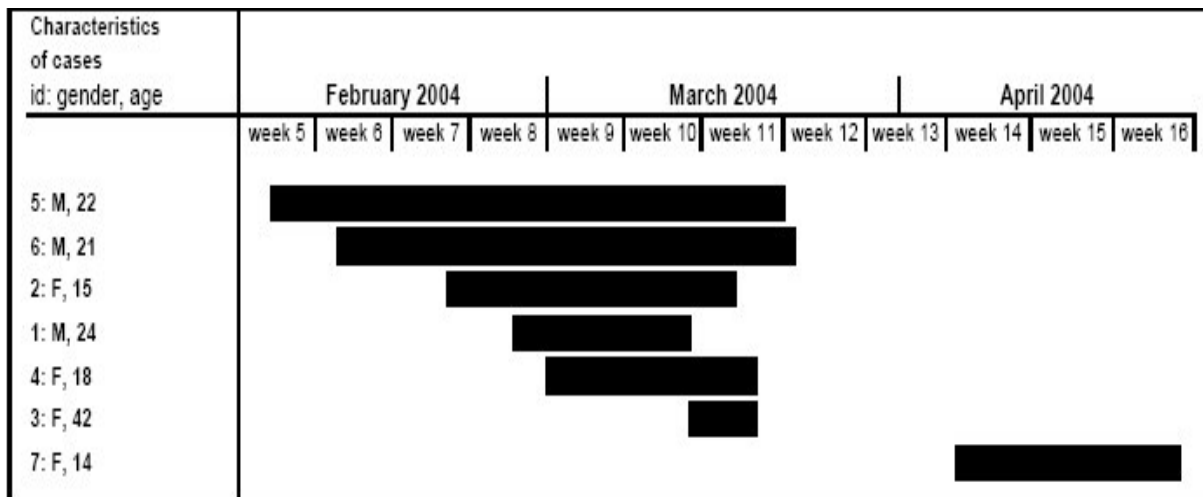


Figure 1. Characteristics, temporally dynamic and relationships amongst 7 death cases (5th February - 26th April, 2004). The cases are identified by the order of death occurrence.

Organophosphates (OP)

They are general name for esters of phosphoric acid of which names of active subject are most of the time recognizable by the ending of their commercial name in "phos" or in "thion". The diagnostic of poisoning by OP is essentially clinical because of the accumulation of acetylcholine in the 3 sites:

- i) Parasympathetic postganglionic fibers hence the muscarinic effects including bradycardia, pinpoint pupils, sweating, blurred vision, excessive lacrimation excessive bronchial secretions, wheezing, dyspnoea, coughing, vomiting, abdominal cramping, diarrhea and urinary and fecal incontinence.
- ii) Nicotinic effects are those of sympathetic over activity and neuromuscular dysfunction and include tachycardia, hypertension, dilated pupils, muscle fasciculation and muscle weakness.
- iii) Cerebral from which the central effects. Accidental ingestion of these poisons may produce death from heart failure unless treated with a suitable antidote. Atropine blocks the receptor site to decrease the stimulant effects produced by the muscarine type poisons, but has no effect on nicotine receptors (Rennes, 2001).

Organochlorides (OC)

They are chemical synthetics from chlore molecules and used for diverse purposes, as insecticides, fungicides and freshening. Frequent in the environment and the food chain (Calamari et al., 1991; Diop et al., 1999), their lipophilicity is the cause of their residual power (MacDougall et al., 1994; Maas et al., 1995; Diouf et al., 1998). They

are the cause of a central nervous break down, preceded by an agitation, eventual digestive troubles disorientation and convulsions. Although the environmental investigation has shown a situation of insalubrity with the presence of cockroaches and mice, no weed-killer, or insecticide were found, except some spirals of anti-mosquitoes (Yo-Tox[®]) found in the bedrooms of the 2 apartments of which their quality could not explain the level of poisoning.

Monoxyde of carbone

Although the house was badly ventilated, there was no boiler, or water heater which could have been damaged. Beside, the clinical signs were stereotyped with the same intensity for all the victims and grew progressively worse, although the patients were out of reach of any risk.

Bromure of metyle

These molecules were usually non-dosable in the biological liquids. On the other hand the presence of a big quantity of brome in the blood increases artificial chloremia in the first Serum electrolytes, which then became normal.

Chronic ergot poisoning (ergotism)

It is a form of fungal poisoning caused by the ingestion of the ergot fungus ascomycete *Claviceps purpurea*. It infects porridge and breads made from the grain. But neither corn wheat, nor wheat which contains the most

parasites. By this, mushroom is used in Senegal. Such diagnosis can be evocated by the autopsy results.

Poisoning by *Detarium* sp (*heudelotianum*)

This is a very toxic variety of a fruit commonly used in Senegal (*Detarium senegalensis*), especially from the region where the death cases occurred (Imbert and Teyssier, 1986).

Poisoning by heavy metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic, highly toxic or poisonous at low concentrations. Between 2005 and 2006, four waves of lead poisoning involving batteries were reported in Dakar suburb. First, it killed the animals (Lo and Diagne, 2007); goats, street dogs and chickens died in handfuls, then en masse. Then it killed the children; toddlers, women birthed stillborns and infants withered and died. Some said the houses were cursed while others said the families were cursed. The mysterious illness killed 18 children in the town situated on the fringes of Dakar, Senegal's capital, before anyone from the outside world noticed. The absence of opacity on the radiography of the abdomen without preparation and the absence of diarrhoea were not favourable respectively.

This could not be a criminal origin rather it must be a domestic poisoning accident by a common source related to a badly conserved food. During the investigation, the inhabitants were told to leave the building and to present themselves at the headquarters nursery in case of any related symptoms. In Senegal, accidents caused by handling domestic or professional products have been reported with an unidentified cause (Gomes et al., 2002). Such as in many developing countries, the diagnosis and the case management of poisoning are a real challenge in the health services (Diop et al., 1999). In June 2007, despite the notion of frequent handling of pesticides for the transformation of seafood, the autopsy on 2 victims, and the aetiology of 4 death cases in Saint-Louis (250 km from Dakar) has remained unexplained (Lo and Diagne, 2007). A four-year retrospective study on the causes of poisoning has shown that among 175 cases, 98.8% were voluntary poisoning (Diop-Ndoye et al., 2005).

Conclusion

Whatever the application place of a pesticide, only a small quantity really reaches the target: undesirable grass, damaging insect, fungus. The rest is diffused in the different compartments of the environment: water, ground, air. Nowadays, the pervasive use of pesticides in

agricultural areas has led to the deterioration of the quality of ground water and surface water, resources earmarked for human consumption. Interactions within the soil determine the fate of environmental pesticides. Water resource contamination may persist for a long time after the last use of pesticides. Pesticide persistence is highly variable. The fate and persistence of pesticides in the environment depend on agricultural pesticide practices and on soil interactions, which are interrelated with physical, chemical and biological processes that are often site specific.

The cause of the death cases is probably linked to a pesticide poisoning considering the decrease of the enzyme choline esterase activity among the cases, which is an indirect biological marker. Several possible etiologies of poisoning in an African context were discussed. Several incidents of the kind have been reported in Africa, with a fatal issue for which formal etiology is not established. These phenomena are put on the account of fatality. This investigation should raise recommendations for:

- i) The setting up at the sub-regional level, an anti-poison centre.
- ii) The training of medical staff for the management of cases of intoxication by pesticide.
- iii) provision of information to the population about the risk of intoxication by toxic agents.

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REFERENCES

- Calamari D, Bacci E, Focardi S, Gaggi C, Morosini M, Vighi M (1991). Role of plant biomass in the global environmental partitioning of chlorinated hydrocarbons. *Environ. Sci. Technol.* 25: 1489-1495.
- Diop YM, Diouf A, Fall M, Thiam A, Ndiaye B, Ciss M, Ba D (1999). Pesticide bioaccumulation: Measurement and levels of organochlorine residues in products of vegetable origin. *Dakar Med.* 44:153-157.
- Diop-Ndoye M, Diallo A, Ndiaye M, Niang B, Wade HK, Fall M, Diatta B (2005). Acute drugs poisoning in hospital principal of Dakar: Epidemiological clinical and therapeutic. A report of 85 cases. *J. Maghrébin d'anesthésie réanimation et de médecine d'urgence* pp. 45-48.
- Diouf A, Ciss M, Diop Y, Boye CS, Diouf S, Fall M, Diop A, Ba D (1998). Well water pollution in the Khombole district: Research on the contamination by organochlorine pesticide residues and organic substances (feces). *Dakar Med.* 43: 157-160.
- Faure E (2009). Le botulisme. <http://www.caducee.net/DossierSpecialises/infection/botulisme.asp>.
- Gomes Do Espirito Santo ME, Marrama L, Ndiaye K, Coly M, Faye O (2002). Investigation of deaths in an area of groundnut plantations in Casamance, South of Senegal after exposure to Carbofuran, Thiram and Benomyl. *J. Expo. Anal. Environ. Epidemiol.* 12: 381-388.
- Imbert P, Teyssier J (1986). Acute poisoning by ingestion of ditakh. A propos of 8 cases. *Med. Trop.* 46: 79-83.

- Lo SF, Diagne MK (2007). Four suspicious deaths in a same family. http://www.lesoleil.sn/article.php3?id_article=25947.
- Maas RP, Kuchen DJ, Path SC, Peek BT, Van-Engelen DI (1995). Pesticides in Earsten North Carolina rural supply wells: Land use factors and persistence. *J. Environ. Qual.* 24: 426-431.
- Macdougall KW, Wan H, Harris CR (1994). The ability of dieldrin, aldrin, lindane, chlopiriphos and protiofos in stored roof water. *J. Environ. Sci. Health* pp. 293-301.
- Rennes IUdMdTd (2001). Intoxication par les insecticides organo-phosphorés. <http://www.med.univ-rennes1.fr/resped/s/medtra/insecticides.htm>.
- Sy MD (2003). Présentation de trois épidémies par intoxication aux pesticides en Casamance. *Médecine d'Afrique Noire* pp. 473-474.
- Tall A, Sall AA, Faye O, Diatta B, Sylla R, Faye J, Faye PC, Ly AB, Sarr FD, Diab H, Diallo M (2009). Two cases of Crimean-Congo haemorrhagic fever (CCHF) in two tourists in Senegal in 2004. *Bull. Soc. Pathol. Exot.* pp.102159-102161.