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Abstract

Chloredecone, an organochlorine insecticide, was widely used in the French West Indies banana plantations. We set up a cohort of banana plantation workers who worked between 1973 and 1993, the period of authorized use of chlordecone. Vital status and causes of death were collected from French national registries. Workers were followed-up from 1 January 2000 to 31 December 2015. Cause-specific mortality in the cohort was compared to that of the general population of the French West Indies by computing standardized mortality ratios (SMRs). A total of 11112 workers (149526 person-years, 77% men) were included in the mortality analysis, and 3647 deaths occurred over the study period. There was a slight deficit in all-cause mortality, which was statistically significant in men (SMR=0.93, 95% CI 0.89-0.96), but not in women (SMR=0.96, 95% CI 0.89-1.04). All-cancer mortality did not differ significantly from that of the general population (men: SMR=0.96, 95% CI 0.90-1.03; women: SMR=1.04, 95%CI 0.89-1.21). Significant excesses of deaths were observed for stomach cancer in women (SMR=1.94, 95% CI 1.24-2.89) and pancreatic cancer in women farm owners (SMR=2.31, 95% CI 1.06-4.39). Mortality from prostate cancer was similar to that of the general population in the whole cohort (SMR=1.00; 95% CI 0.89-1.13), and non-significantly elevated among farm workers (SMR=1.10, 95%CI 0.87-1.36). Non-significant increases in mortality were also observed for lung cancer in women, leukemia in men and non-Hodgkin lymphoma in both genders.

Keywords: banana plantations, French West Indies, occupational cohort, mortality, standardized mortality ratio (SMR), pesticides

Introduction

Chlordecone is an organochlorine insecticide that was used intensively in the French West Indies, Guadeloupe and Martinique, from 1973 to 1993 to control banana root borers. Chordecone was initially produced in the USA, from the early 1960's to 1975. It was used in the USA as an insecticide for non-food products, was exported in Central America, in the Caribbean and in Africa for banana crops, and in Europe for conversion into an adduct, kevelan, for use on Colorado potato beetles in Eastern European countries. The production and use were prohibited in the USA in 1976. Chlordecone was marketed again by a French company in 1981 and was since then used almost exclusively in the French West Indies, until it was banned in 1993 (ATSDR 2019, Le Déault and Procaccia 2009). As this pesticide undergoes no significant biotic or abiotic degradation in the environment, its use has resulted in permanent soil and water pollution (Cabidoche et al. 2009, Coat et al. 2011) and in a consequent contamination of foodstuffs. Nowadays, the population is still exposed, mainly through food (Dubuisson et al. 2007, Guldner et al. 2010). Chlordecone is considered to be an endocrine disruptor and a potential carcinogen, and is a cause of serious local concern. Several epidemiological studies have been conducted in the French West Indies to assess the impact of environmental exposure to chlordecone on the health of the population (Multigner et al. 2016). However, no large-scale epidemiological study has so far specifically addressed the population of agricultural workers. These workers are likely to have been exposed to higher levels than the general population, because they have cumulated the common dietary exposure with occupational exposure. Indeed, a study on male fertility showed that even in the mid-2000s, more than 10 years after the ban on the agricultural use of chlordecone, blood chlordecone concentrations were significantly higher in banana workers than in men who worked in nonagricultural sectors (Multigner et al. 2016).

The study of agricultural workers can help improve knowledge of long-term health effects of chlordecone exposure. The implementation of an epidemiological surveillance of workers also meets the high expectations of local authorities and workers' organizations, and may have implications for occupational diseases compensation. In order to study the health of this population, a historical cohort of banana plantation workers potentially exposed to chlordecone has been established. The primary objective is to analyze cause-specific mortality, with a special interest in cancer mortality. Possible effects of chlordecone exposure are the main focus, but this cohort will also provide an overview of various health outcomes in banana plantation workers, a population very highly exposed to pesticides, but only little studied so far. While several studies have examined acute effects of pesticide exposure on banana workers, to our knowledge long-term health effects have only been assessed in a single cohort of banana plantation workers in Costa Rica (Wesseling et al. 1999, Hofmann et al. 2006). More generally, current knowledge on the health effects of pesticides has been derived from studies conducted predominantly in North America and Europe (Blair et al. 2014). Studies of agricultural workers in tropical environments, where climatic conditions lead in a heavier use of pesticides than in temperate areas, can provide additional insight.

We present here the methods used to construct the cohort and the first results on mortality for the period 2000-2015.

Material and methods

Cohort construction

A cohort of farm owners and farm workers, who had worked on a banana plantation in Martinique or Guadeloupe between 1973 and 1993, the period of authorized use of chlordecone, was set up retrospectively. The primary data sources used to construct the cohort were the general agricultural censuses and archives of the General Social Security Funds (CGSS, Caisses Générales de Sécurité Sociale) of Guadeloupe and Martinique.

General agricultural censuses periodically collect information on all agricultural holdings. We used data from the 1973, 1981 and 1989 censuses, which were relevant for the period of interest. All paper questionnaires were examined and holdings with an area dedicated to banana cultivation of at least 0.01 hectare (100 m^2) were identified and selected. Information from the questionnaires was used to compile a list of farm owners, including surnames, first names, gender and date of birth (year of birth only for the 1973 census). Data on farms were also collected: total area, banana area, area dedicated to other crops, animal husbandry, number of permanent employees, number of seasonal employees, etc.

Farm owners from the list were then searched in the archives of the General Social Security Funds to complete personal identification data necessary to search for vital status and causes of death (gender, name, first names, date and place of birth, see below), as well as data on job history.

In France, it is mandatory for each company, including agricultural holdings, to provide information on employees on an annual basis (Déclaration annuelle des données sociales (DADS), annual declaration of social data), including names, gender and date of birth. The list of employees of a given farm is therefore available year by year. These declarations are also archived in the General Social Security Funds, and were used to compile a list of farm workers from the list of banana plantations. Personal identification information and job history were then completed as for farm owners.

The inclusion process is summarized in Figure 1.

Follow-up, vital status and causes of death

Vital status, as well as the date and place of death for deceased workers were obtained for the period 1973-2015 from the French national vital status registry (Répertoire National d'Identication des Personnes Physiques), by matching on gender, name, first names, date and place of birth.

Causes of death were obtained from the French national mortality registry (Centre d'épidémiologie sur les causes de décès, CepiDC), by matching on gender, date of birth, date and place of death. Causes of deaths that occurred in the French overseas regions before the year 2000 are not currently included in this registry. The study of cause-specific mortality was therefore restricted to workers who were still alive on 1 January 2000. For each worker, follow-up began on 1 January 2000 and ended at date of death or 31 December 2015. whichever occurred first.

Underlying and associated causes of death were coded according to the International Classification of Diseases, 10th Revision (ICD 10).

Statistical analysis

We computed standardized mortality ratios (SMRs), using the general population of the French West Indies (Guadeloupe and Martinique) as the reference population. Regional mortality rates were provided by the CepiDC. SMRs were computed separately for men and women, controlling for age (15–19, 20–24,…, ≥95 years) and calendar period (2000-2003, 2004-2007, 2008-2011, 2012-2015). Exact 95% confidence intervals were calculated under the Poisson assumption.

All-cause mortality included deaths with non-identified causes. For non-cancer causes of deaths, SMRs were calculated for the major headings of the European short list of causes of deaths (Eurostat 2012) and for sub-categories with at least 20 deaths in the whole cohort. Cancer mortality was studied in more detail; SMRs were computed for 15 cancer sites or group of sites. The categories of causes of deaths used in the analysis and the corresponding

ICD 10 codes are provided in Table S1 in supplementary material. SMRs were not calculated when the number of observed deaths was less than 3.

Primary analyses were based on the underlying cause of death. Supplementary analyses, taking into account associated causes of death were also performed. We also computed SMRs for two calendar periods of follow-up: 2000-2007 and 2007-2008. In addition, we conducted analyses separately for farm owners and farm workers. In these analyses, those who had worked both as farm workers and as farm owners were classified as farm owners. Finally, to assess the effect of the exclusion of deaths and person-years prior to 1 January 2000, we calculated all-cause mortality SMRs for the period 1973-1999. For these analyses, person-years and deaths were counted from the most recent date among 1 January 1973 and mid-year of first employment and ended at date of death or 31 December 1999.

Analyses were conducted using SAS software, V.9.4 (Cary, North Carolina, USA).

Results

We initially identified 14638 eligible workers. We excluded 939 workers who had insufficient personal data to match the national files. We further excluded 282 workers who were not found in the national vital status registry, or for whom the linkage was ambiguous. The final cohort was comprised of 13417 workers (10579 men and 2838 women). Among them, 11112 were still alive on 1 January 2000 and were included in the mortality study. The main characteristics of this cohort are shown in Table 1. Most of the workers (77%) were men. Among the 11112 included workers, 4253 were from Guadeloupe and 6859 were from Martinique. The cohort is composed of 5209 farm owners, of whom 274 had also worked as farm workers, and of 5903 farm workers. Almost all workers were born before 1960. The average age at the beginning of the follow-up was 60 years. A total of 3647 deaths occurred during the follow-up period, and the cause of death was retrieved for 3610 (99%) of them. The workers under study contributed 149526 person-years of observation (114458 in men, 35068 in women).

The 11112 included workers had worked in a total of 6513 banana plantations. Descriptive data for these plantations are presented in Table 2. Most of these plantations were small in size, with less than one hectare devoted to banana cultivation for 40% of them. Only 16% had permanent employees, and 3.6% had more than 10 employees. These features are similar to those of banana plantations in the French West Indies in the period 1970-1990 (Agreste, 1976, 1984, 1990). Most of the farms were mainly devoted to banana cultivation, but 64% had other associated crops, mainly market gardening and food crops (42%), as well as sugar cane (9%) and fruit trees (5%). Other crops (pineapple, flowers, vanilla, aromatic plants) were found on less than 5% of the plantations. Animal husbandry was present on 70% of the farms.

Table 3 shows the SMRs for non-cancer causes of death. Compared to the general population of the French West Indies, there was a slight deficit in all-cause mortality, which was statistically significant in men, but not in women. No statistically significant excess was observed, for any cause of death. In men, most SMRs were below 1. Non-significantly elevated SMRs were found in men only for alcohol abuse, Parkinson disease, cerebrovascular diseases, chronic lower respiratory diseases and diseases of the skin. Mortality from Alzheimer's disease was elevated in women but not in men. Slight and non-significant excesses were also observed in women only for deaths from infectious diseases, nutritional and metabolic diseases, diseases of the genitourinary system and of the musculoskeletal system. In addition, in women, there was a significant deficit of deaths from digestive diseases overall, but a non-significant excess of deaths from chronic liver diseases. Mortality by suicide was non-significantly increased in both men and women.

Cancer mortality is presented in Table 4. All-cancer mortality did not differ significantly from that of the general population. Mortality from stomach cancer was significantly increased in women, and non-significantly increased in men. A significant deficit in deaths from liver cancer was found in men only. No other SMR was statistically significant. Non-significant excesses were observed in both genders for bladder cancer and non-Hodgkin lymphoma. Non-significantly elevated SMRs were also observed in men only for cancers of the buccal cavity/pharynx and for leukemia, and in women only for cancers of the pancreas and larynx/lung. Mortality from prostate cancer was similar to that of the general population. A non-significant deficit was observed for mortality from breast cancer.

Taking into account associated causes of death in addition to the underlying cause did not modify the results. In particular, the SMRs remained virtually unchanged for stomach cancer (women: SMR=1.88, 95% CI 1.22-2.78, 25 observed deaths; men: SMR=1.11, 95% CI 0.90-1.36, 93 observed deaths), prostate cancer (SMR=1.00, 95% CI 0.90-1.11, 354 observed deaths), and breast cancer (women: SMR=0.74, 95% CI 0.43-1.18, 17 observed deaths; men: 2 observed deaths vs 2.00 expected).

The SMRs did not differ markedly according to the period of follow-up (see Table S2 in supplementary material). For most causes of death, the SMRs were slightly higher in the most recent period (2008-2015). The SMR for stomach cancer in women was nevertheless statistically significant only in the period 2000-2007 (SMR=2.15, 95% CI 1.14-3.67, 13 observed deaths), although it remained elevated in the period 2008-2015 (SMR=1.64, 95% CI 0.82-2.93, 11 observed deaths).

Analyses in farm workers and farm owners did not reveal strong specificities. Results for the most frequent cancer sites (at least 50 observed deaths in the whole cohort) are presented in Table 5. For stomach cancer, the highest SMR, statistically significant, was found in female farm owners. Elevated although non-significant SMRs were also observed in farm workers of both genders, whereas stomach cancer mortality was not increased in male farm owners. There was a significant excess of deaths from pancreatic cancer among female farm owners only. Mortality from lung and laryngeal cancers was non-significantly increased in female farm workers. Mortality from prostate cancer was slightly increased in farm workers, but not in farm owners. The SMRs were also higher in male farm workers than in male farm owners for lymphohematopoietic malignancies. No important differences between farm workers and farm owners were found for the other cancer sites, or for non-cancer mortality (see Table S3 in supplementary material).

During the period 1973-1999, among men, 1983 deaths were observed (vs 3115.0 expected), leading to a significant deficit (SMR=0.64, 95% CI 0.61-0.67). A significant deficit of deaths from all causes was also observed among women (322 observed deaths, 552.8 expected, SMR=0.58, 95% CI 0.52-0.65). The SMRs for all-cause mortality were lower in 1973-1999 than during the period 2000-2015, for both men and women.

Discussion

The present study provides for the first time a description of mortality patterns during the period 2000-2015 in this population of banana plantation workers in the French West Indies. Overall, mortality was close to that of the general population. Nevertheless, excesses of deaths from some specific cancer sites deserve further attention.

Although the cohort was designed to include only banana plantation workers who worked during the period of authorized use of chlordecone, the present results should not be interpreted in terms of associations between chlordecone exposure and specific diseases. First, banana plantation workers have been exposed to a number of different pesticides in addition to chlordecone, and to physical and biological nuisances. Mortality in the cohort was therefore also influenced by these other occupational exposures, as well as by non occupational risk factors. On the other hand, it is clear that the levels of past chlordecone exposure vary within the cohort, and that the cohort may include workers who had not been occupationally exposed. The consequent dilution of risk in the whole cohort may have hidden possible excesses in some subgroup of workers. The purpose of this analysis, however, was to provide a general picture of the mortality experience in this cohort of banana workers, relative to the general population. Such comparisons have been found to be useful and have been widely used in occupational epidemiology. It is important to note, however, that mortality studies, while informative, do not capture adequately the incidence of rarely fatal diseases.

Compared to the general population, for the period 2000-2015 all-cause mortality in the cohort was slightly but significantly lower in men, and non-significantly lower in women. An overall lower mortality relative to the general population, known as the healthy worker effect, is typically observed in occupational cohorts. In the present study, the healthy worker effect was much less marked than in other cohorts of agricultural workers (Blair 1992 et al., Acquavella et al. 1998, Blair and Freeman 2009, Waggoner et al. 2011, Leveque-Morlais et al. 2015). This is due to the exclusion of the earlier years of follow-up. Indeed, the healthy worker effect was strongest during the early years of follow-up (1973-1999) and attenuates over time, as usually observed in occupational cohorts (Checkoway et al. 2004).

No statistically significant excesses occurred for non-cancer causes of deaths. The elevated SMR observed in men for alcoholism suggests that this population may have had a higher consumption of alcohol than usually observed in agricultural workers (Waggoner et al. 2011, Leveque-Morlais et al. 2015). Mortality from chronic lower respiratory diseases was non-significantly increased in men. Agricultural work has been associated with a greater risk of developing chronic obstructive pulmonary disease (Guillien et al. 2019). The elevated mortality by suicide, although non-significant, is consistent with the high suicide rate in agricultural workers reported in a number of studies (Milner et al. 2013, Klingelschmidt et al. 2018). An increased risk of Parkinson’s disease has been observed in agricultural workers in general (Van Maele-Fabry et al. 2012), and specifically in banana plantations workers (Hofmann et al. 2006), and Alzheimer’s disease has also been associated with exposure to pesticides (Yan et al. 2016). In our study, the SMR for Parkinson’s disease was only slightly elevated in men, and decreased in women, whereas the SMR for Alzheimer’s disease was elevated in women and decreased in men. However, a mortality study like ours is not well suited to the study of neurodegenerative disorders.

Cancer mortality overall did not differ from that of the general population. However, excess deaths, mostly non-significant, were observed for several cancer sites.

We found an excess of deaths from stomach cancers, which was more evident in women. Elevated stomach cancer risk in comparison to the general population has been reported in several studies of agricultural workers (Blair and Freeman 2009, Bucchi et al. 2004, Krawczyk et al. 2017).

Increased risks of Non-Hodgkin lymphoma, multiple myeloma, and leukemia have been consistently observed in agricultural populations (Blair and Freeman 2009, Khuder and Mutgi 1997, Khuder et al. 1998, Van Maele-Fabry et al. 2007). We observed non-significant excesses of Non-Hodgkin lymphoma in both genders, and a non-significant excess of leukemia among men only, but no excess of death from multiple myeloma.

Most studies of farmers showed a strong deficit of lung and laryngeal cancers (Blair and Freeman 2009, Waggoner et al. 2011, Leveque-Morlais et al. 2015, Kachuri et al. 2017, Krawczyk et al. 2017) attributed to a lower smoking prevalence in agricultural workers than in the general population. We did not observe such a deficit in the present study, with non-significant SMRs of 0.91 in men and 1.31 in women. Smoking prevalence is low in the French West Indies (Richard 2015), and differences in smoking rates between farmers and the general population may be less pronounced than in other countries. It should be noted that non-significantly elevated risks for lung cancer were observed in banana plantation workers in Costa Rica (Wesseling et al. 1999, Hofmann et al. 2006). In addition, despite an overall reduced risk of lung cancer among farmers, positive associations between lung cancer and several pesticides have been reported (Bonner et al. 2017, Alavanja et al. 2004).

The significantly elevated SMR for pancreatic cancer in female farm owners is intriguing. No excess was observed in men or in female farm workers. This result may be due to chance. However, two other studies observed similarly increased risks of pancreatic cancer among female, but not male, agricultural workers (Kachuri et al. 2017, Alguacil et al. 2000).

Overall, mortality from prostate cancer in the cohort was similar to that of the general population (SMR=1.00; 95% CI 0.89-1.13), and a non-significant excess was observed among farm workers (SMR=1.10, 95%CI 0.87-1.36). Several meta-analyses on the risk of prostate cancer among farmers found slight but significantly elevated meta-relative risks, ranging from 1.07 to 1.13 (Blair et al. 1992, Keller-Byrnes et al. 1997, Acquavella 1998, Van Maele-Fabry and Willems 2003). These findings are overall compatible with our results. An association between chlordecone exposure and prostate cancer risk has been previously reported in Guadeloupe, with a significantly increased risk in the highest quartile of cumulative exposure (Multigner et al. 2010). Our data do not contradict these results. As explained above, the overall lack of excess deaths in the whole cohort does not preclude the possibility of excess deaths in some subgroups of workers, notably those exposed to the highest levels of chlordecone.

A limitation of our study is that no data on causes of death were available before 2000, due to the lack of inclusion of deaths from overseas regions in the national mortality registry. As a consequence, the study of cause-specific mortality was restricted to workers still alive in 2000. This restriction to survivors may have led to an underestimation of risk. However, the SMRs for all causes of death were lower for the period 1973-1999 than for the period 2000-2015. In addition, in our study, the SMRs were generally slightly higher during the later period of follow-up (2008-2015) than during the earlier period (2000-2007). This suggests that overall the SMRs would not have been higher if it had been possible to trace all causes of death. However, whether the exclusion of workers who died before 2000 had probably only limited consequences for diseases with a long latency time, such as most solid cancers, this is not the case for diseases with shorter latency, such as lymphohematopoietic malignancies. More generally, short or medium-term health effects could not be properly assessed in the present study.

Perspectives

The study will continue with internal analyses in which mortality will be analyzed according to the characteristics of workers (employment status, period and duration of employment) and farms (banana area, presence of other crops and livestock). The causes of death for the period 1981-2000 are currently being incorporated into the National mortality registry, and should soon be available, which will make it possible to complete the follow-up. In a second step, it is planned to assess exposures to chlordecone and other pesticides using the crop-exposure matrices developed for French West Indies (Gentil et al. 2018), and to analyze workers' mortality according to the exposure levels. Later, it will be possible to study other outcomes, in particular cancer incidence based on data from cancer registries, implemented since 1983 in Martinique and 2008 in Guadeloupe. Overall, this cohort will be a valuable tool for epidemiological surveillance and research on the long-term effects of occupational exposure to chlordecone and other pesticides in workers of banana plantations.

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Compliance with ethical standards

The study was approved by the Institutional Review Board of the French National Institute of Health and Medical Research (IRB-INSERM, n° 15-193), and by the French Data Protection Authority (CNIL n° DR-215-200). Access to the nominative questionnaires of the agricultural censuses was authorized by the Committee on Statistical Confidentiality of the National Institute of Statistics and Economic Studies (session 14 January 2015, n°E270).

The authors declare no conflict of interest.

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Fig 1 Cohort construction

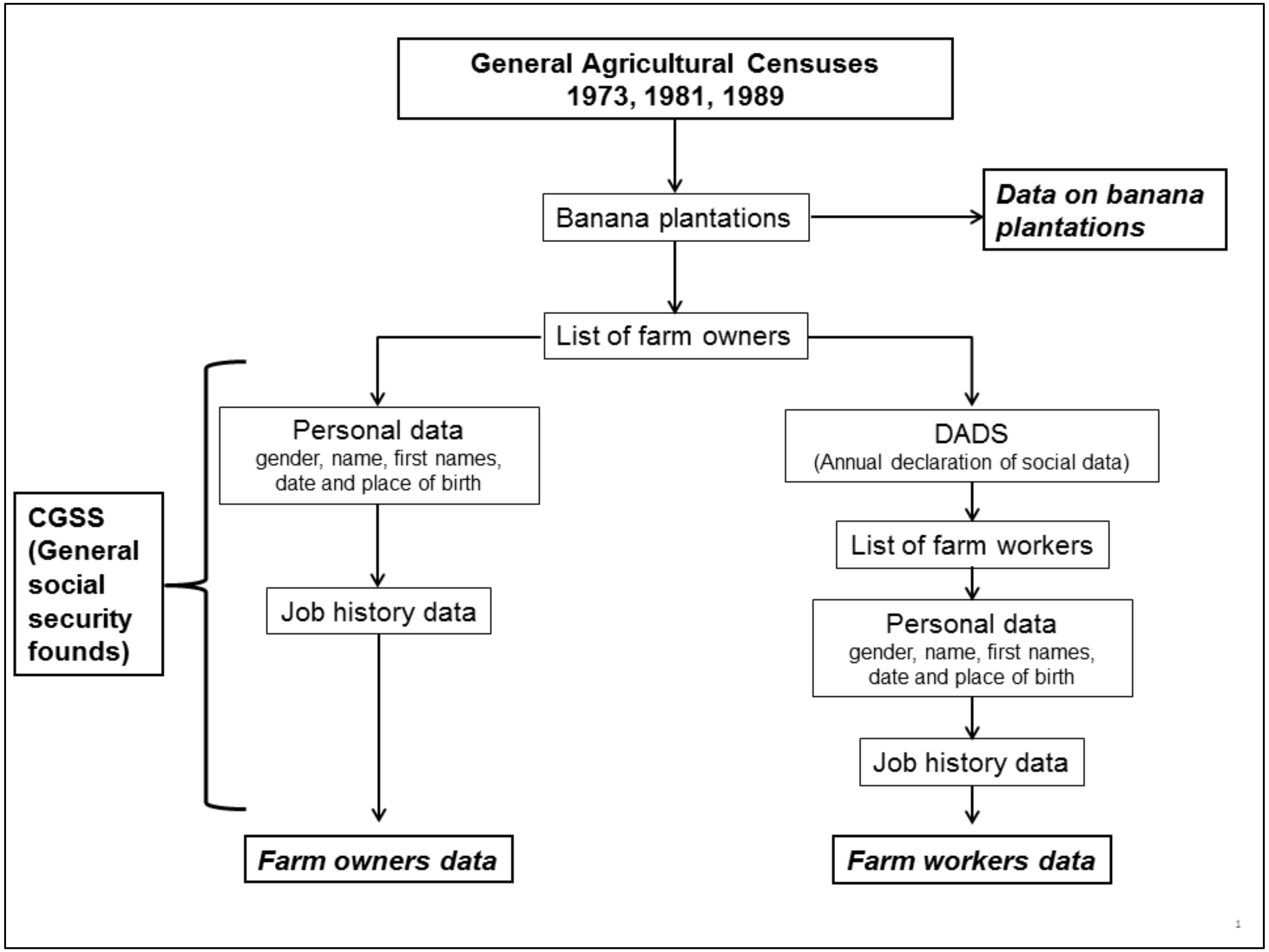

Table 1 – Description of the cohort

	N	%
All workers	11112	
Gender		
Men	8597	77.4
Women	2515	22.6
Region		
Guadeloupe	4253	38.3
Martinique	6859	61.7
Employment status		
Farm owners	5209	46.9
Farm workers	5903	53.1
Year of birth		
<1910	134	1.2
1911-1920	862	7.8
1921-1930	2284	20.6
1931-1940	2696	24.3
1941-1950	2187	19.7
1951-1960	2268	20.4
1961-1970	644	5.8
>1970	37	0.3
Age at beginning of follow-up(mean ± SD)	60.1 ±0.1	
Deceased on 31 December 2015	3647	32.8
Age at death (mean ± SD)	79.0 ±0.2	

Table 2 – Main characteristics of the banana plantations

	N	%
Total	6513	
Banana area (ha)		
< 0.1	480	7.4
[0.1-0.5[	1230	18.9
[0.5 - 1[	1049	16.1
[1-2[	1321	20.3
[2-4[	1279	19.6
[4-10[	670	10.3
≥ 10	484	7.4
Number of permanent employees		
0	5444	83.6
1-2	457	7.0
3-5	247	3.8
6-10	132	2.0
11-49	196	3.0
≥ 50	37	0.6
% of utilized agricultural area devoted to banana		
> 90%	2880	44.2
50-90%	1731	26.6
< 50%	1902	29.2
Other crops	4193	64.4
Food and market-garden crops	2702	41.5
Sugarcane	562	8.6
Fruit trees	344	5.3
Animal husbandry	4527	69.5

Table 3 – Standardized mortality ratios for all causes and non-cancer causes of death

	Men				Women			
	exp	obs	SMR	95% CI	exp	obs	SMR	95% CI
All causes	3155.5	2924	0.93	0.89-0.96	751.1	723	0.96	0.89-1.04
Infectious and parasitic diseases	98.24	84	0.86	0.68-1.06	23.36	28	1.20	0.80-1.73
Diseases of the blood and blood-forming organs	12.60	9	0.71	0.33-1.36	3.89	2	/	/
Endocrine, nutritional and metabolic diseases	180.71	156	0.86	0.73-1.01	65.35	68	1.04	0.81-1.32
Diabetes mellitus	121.78	116	0.95	0.79-1.14	50.22	51	1.02	0.76-1.34
Diseases of the digestive system	134.47	127	0.94	0.79-1.12	31.23	19	0.61	0.37-0.95
Cirrhosis, fibrosis and chronic hepatitis	35.77	32	0.89	0.61-1.26	4.17	5	1.20	0.39-2.80
Mental and behavioural disorders	84.81	74	0.87	0.69-1.10	13.49	13	0.96	0.51-1.65
Alcohol abuse (incl. alcoholic psychosis)	36.97	41	1.11	0.80-1.50	1.02	0	/	/
Diseases of the nervous system and the sense organs	166.70	162	0.97	0.83-1.13	44.40	47	1.06	0.78-1.41
Parkinson disease	36.57	38	1.04	0.74-1.43	5.76	3	0.52	0.11-1.52
Alzheimer’s disease	68.62	59	0.86	0.65-1.11	28.28	37	1.31	0.92-1.80
Diseases of the circulatory system	868.45	816	0.94	0.88-1.01	239.97	220	0.92	0.80-1.05
Ischemic heart diseases	113.74	99	0.87	0.71-1.06	27.37	26	0.95	0.62-1.39
Other heart diseases	218.08	208	0.95	0.83-1.09	66.28	57	0.86	0.65-1.11

Cerebrovascular diseases	306.80	324	1.06	0.94-1.18	88.40	71	0.80	0.63-1.01
Diseases of the respiratory system	176.92	159	0.90	0.76-1.05	37.66	31	0.82	0.56-1.17
Pneumonia	73.15	70	0.96	0.75-1.21	17.36	16	0.92	0.53-1.50
Chronic lower respiratory diseases	32.92	37	1.12	0.79-1.55	6.11	5	0.82	0.27-1.91
Diseases of the skin and subcutaneous tissue	14.33	18	1.26	0.74-1.99	5.27	3	0.57	0.12-1.66
Diseases of the musculoskeletal system/connective tissue	13.13	9	0.69	0.31-1.30	4.54	7	1.54	0.62-3.18
Diseases of the genitourinary system	67.91	63	0.93	0.71-1.19	13.63	14	1.03	0.56-1.72
Diseases of kidney and ureter	42.28	37	0.88	0.62-1.21	10.86	11	1.01	0.51-1.81
External causes	163.65	131	0.80	0.67-0.95	23.10	25	1.08	0.70-1.60
Transport accidents	25.23	22	0.87	0.55-1.32	1.75	2	/	/
Suicide	24.66	26	1.05	0.69-1.55	1.47	3	2.04	0.42-5.95
Symptoms, signs, ill-defined causes	316.99	261	0.82	0.73-0.93	86.34	75	0.87	0.68-1.09

obs: observed deaths; exp: expected deaths

Table 4 – Standardized mortality ratios for cancer deaths

Cancer site	Men				Women			
	exp	obs	SMR	95% CI	exp	obs	SMR	95% CI
All cancers	854.12	823	0.96	0.90-1.03	158.22	165	1.04	0.89-1.21
Lip, buccal cavity, pharynx	28.23	34	1.20	0.83-1.68	1.24	0	/	/
Esophagus	25.16	23	0.91	0.58-1.37	1.47	2	/	/
Stomach	76.00	82	1.08	0.86-1.34	12.37	24	1.94	1.24-2.89
Colon and rectum	61.43	49	0.80	0.59-1.05	17.39	18	1.04	0.61-1.64
Liver	29.51	13	0.44	0.23-0.75	5.73	5	0.87	0.28-2.04
Pancreas	41.69	35	0.84	0.58-1.17	11.59	15	1.29	0.72-2.14
Larynx, trachea, bronchus and lung	79.36	72	0.91	0.71-1.14	9.95	13	1.31	0.70-2.23
Breast	1.76	2	/	/	19.22	14	0.73	0.40-1.22
Uterus					15.40	15	0.97	0.55-1.61
Prostate	268.98	270	1.00	0.89-1.13				
Bladder	16.34	18	1.10	0.65-1.74	2.61	5	1.92	0.62-4.48
Lymphatic and haematopoietic	68.96	75	1.09	0.86-1.36	16.92	12	0.71	0.37-1.24
Multiple myeloma	26.50	24	0.91	0.58-1.35	7.23	3	0.42	0.09-1.21
Non-Hodgkin lymphoma	18.33	22	1.20	0.75-1.82	3.40	6	1.77	0.65-3.86
Leukemia	22.24	27	1.21	0.80-1.76	5.95	3	0.50	0.10-1.46

obs: observed deaths; exp: expected deaths

Table 5 –Standardized mortality ratios for selected cancer sites, among farm owners and farm workers

Cancer site		**Farm owners**				**Farm workers**			
	Gender	exp	obs	SMR	95% CI	exp	obs	SMR	95% CI
Stomach	Women	4.68	12	2.57	1.33-4.48	7.69	12	1.56	0.81-2.73
	Men	50.42	49	0.97	0.72-1.28	25.54	33	1.29	0.89-1.82
Colon and rectum	Women	6.15	6	0.98	0.36-2.12	11.24	12	1.07	0.55-1.86
	Men	38.59	35	0.91	0.63-1.26	22.84	14	0.61	0.34-1.03
Pancreas	Women	3.89	9	2.31	1.06-4.39	7.70	6	0.78	0.29-1.70
	Men	26.37	21	0.80	0.49-1.22	15.33	14	0.91	0.50-1.53
Larynx, trachea, bronchus and lung	Women	3.05	2	/	/	6.90	11	1.59	0.80-2.85
	Men	48.28	40	0.83	0.59-1.13	31.08	32	1.03	0.70-1.45
Prostate	Men	194.35	188	0.97	0.83-1.12	74.61	82	1.10	0.87-1.36
Lymphatic and haematopoietic	Women	5.75	2	/	/	11.18	10	0.89	0.43-1.64
	Men	44.80	45	1.00	0.73-1.34	24.16	30	1.24	0.84-1.77

obs: observed deaths; exp: expected deaths