

Switzerland does not regularly publish data on mortality or morbidity by occupation as some other European countries do. Data on occupational variation in cancer risk have been documented systematically in only two monographs on mortality (1, 2).

Occupation has been coded in the Swiss mortality statistics since the late 19th century. At that time, interest was focused on the determinants of tuberculosis, and several studies were published using occupational information. From the beginning of the 20th century until the middle of the 1980s, occupational information was considered to be of less importance, and practically nothing was published in this respect. In the 1970s, coding was restricted to men and women of working age only, a decision that was fortunately reversed in 1978. In the 1980s, the quality of occupational coding and causes of death was investigated through individual linkage of a random sample of death certificates with census data and hospital records. (See reference 2.) Agreement between the occupation described in the death certificate records and the census records ranged from 92% for physicians to 10% for papermakers, but the majority exceeded 40%. Agreement between cancer diagnoses on the death certificates and the hospital records ranged from 94% for leukemia to 65% for cancer of the larynx. With this information, reliable and scientifically sound studies became feasible. Several of them demonstrated substantial differences in mortality between social and occupational groups (1–9).

Occupational coding was discontinued in mid-1988, and only the wording on the death certificates was retained. Neither text recognition nor record linkage to census records was implemented; therefore, it became impossible to carry out studies on mortality among occupational or socioeconomic groups.

There are potential sources of bias in mortality statistics. Therefore mortality data can be inadequate for assessing risk by socioeconomic groups. For nonfatal cancers, mortality patterns reflect socioeconomic differences in risk and also in survival. It should be noted that

survival differences are due to unequal access to early diagnosis and optimal treatment (10). For instance, less favored persons have been shown to present higher mortality from melanoma than those of the upper class, although the latter are affected more often by this cancer (11). Finally, previous mortality studies have observed an unexpected low mortality among partially skilled and unskilled Swiss workers. This low mortality is probably artificial, being related to the high proportion of foreigners among the least affluent groups (12). In fact, ill foreign workers tend to emigrate and die in their home countries, and thus the mortality statistics are reliable only for Swiss residents. With regard to occupational risk assessment, this immigration bias could be of importance for occupations with a high proportion of foreign workers, such as in construction.

Cancer registers provide diagnostic information of higher quality and detail than death certificates, and they relate cancer risk more accurately than mortality data. Because cancer registries code occupations differently, a systematic analysis of cancer risk by social or occupational groups has not been undertaken at an intercantonal level. The coordinating office of The Association of Swiss Cancer Registries (ASCR) has recently established a common system of classification (ASCR Classification of Occupations) that is compatible with the classifications in use in the registries, and this classification allows comparative analyses to be made (13).

Because of discrepancies in recording and coding information between census and incident cases, the present analysis is based on incident cases only, using the case-referent approach derived from that of proportional analysis (14).

The principal aims of this study were to present an overview of cancer risk patterns by socioeconomic status and occupation in Switzerland, to establish the feasibility of a social and occupational surveillance system by means of the Swiss cancer registries, and to search for clues to occupation-specific factors in order to identify areas of further research and public health intervention.

Materials

The Association of Swiss Cancer Registries

The Association of Swiss Cancer Registries (ASCR) was founded at the beginning of the 1970s to standardize and harmonize the definition and collection of data on cancer incidence. At the end of the 1980s, a common data bank on incident cancer cases was set up, and it is regularly updated by the Swiss population-based cancer registries. Eight regional registries are currently active, covering about half of the resident population of Switzerland (15). Although urban and French-speaking areas are overrepresented, the data provided by ASCR are considered to provide a relatively good estimation of the incidence for the entire country, except for a few cancer sites for which national incidence rates are probably overestimated (eg, urinary bladder cancer) or underestimated (eg, stomach cancer) (15).

Notification to the regional registries is based on a voluntary agreement between the physicians and medical institutions in charge of diagnosis or treatment and the cancer registries. In general, Swiss registries have access to all pathological laboratories and to medical records of public hospitals. Data are systematically abstracted from medical and laboratory records by trained tumor registrars. Several registries regularly address inquiry forms to private practitioners to complete missing data. Recorded data include information on socio-demographic characteristics (age, gender, nationality, marital status, commune of residence, occupation), diagnosis (date and method of assessment of diagnosis), and tumor characteristics (primary site and histological type).

Selection of the population

The data considered for the present analysis were derived from the data set of ASCR. Five of the eight cancer registries have systematically collected information on occupation for more than 2 years (Basel, Geneva, St Gall-Appenzell, Vaud, and Zurich). Their main characteristics are described in table 1. Geneva and Vaud are French-speaking cantons, while Basel, St Gall-Appenzell, and Zurich are German-speaking. These registries cover a population of > 3 million inhabitants (ie, about 45% of the population of Switzerland).

Only invasive malignant tumors were considered. Cancers among women were excluded because of the high percentage of unknown or unclassifiable occupations. For each cancer registry, the selection of data according to time frame and age group are described in

table 2. The study was limited to men ≥ 25 years of age. Men aged > 65 years were excluded in St Gall (N=3322) and Vaud (N=5475), since occupations were unknown or unclassifiable in more than 30% of the cases. The time frame of incidence considered was 1980 to 1993, although this period varied between registries according to the available data on occupation and the latest year for which registry data were considered complete (table 2).

The final series comprised 58 134 incident cancer cases. The distribution of cases by site and registry is described in table 3. The most frequent cancers were of the lung (15.7%) and the prostate (15.7%), followed by nonmelanoma skin cancer (14.3%) and cancer of the colon (6.5%).

Because basal- and squamous-skin carcinomas are of minor importance in terms of lethality and mortality, the cancer registry of Zurich does not register them.

Information on occupations

Switzerland has no central population registry office providing nationwide standardized information on individual occupations. Therefore, cancer registries use various sources of information in documenting occupations. These sources are more or less accessible depending on the registration area. The cantonal and local registry offices in charge of population files and the clinical hospital records are generally the main sources of information. Additional sources, such as death certificates and telephone directories for active individuals, are also used. The sources of occupational information are unfortunately not registered and could therefore not be analyzed. Most registries select the last occupation, while others select the longest occupation, and yet others the occupation at the time of cancer diagnosis (which implies missing information on retired patients) or, in case of doubt, the best specified occupation. The main sources of information are summarized by registry in table 2.

Classification of occupations used by The Association of Swiss Cancer Registries

The cancer registries primarily code occupations using two different classifications (table 2). The classification of vital statistics is applied in two registries (Geneva and Zurich) (16). This classification is, in essence, a rougher version of the classification used in the federal census performed in 1970, by the Swiss Federal Statistical Office. It includes 12 major groups subdivided into 40

submajor groups and 130 minor groups. Other cancer registries used the classification of the federal census performed in 1980, also elaborated by the Swiss Federal Statistical Office (17). The latter classification comprises 12 major groups, 48 submajor groups, and 544 unit groups.

For the sake of compatibility, the elaborated ASCR classification was developed (13). An attempt was made to consider the conceptual and structural differences in the two initial classifications (which, however, are basically similar in structure) and to provide the most homogeneous subgroups for the assessment of cancer risk. The occupational subgroups in the compiled data could therefore not be more accurate than the less-detailed

classification (ie, the earlier one) (16). Occupational profiles were also aggregated if any disparity was suspected between the two classifications or if an occupation was rarely represented (< 5 cases) in the total data set. The frame resulting from this approach consists of 20 major groups at the highest level of aggregation, subdivided into 87 submajor or minor groups. The ASCR classification structure resembles that recently adopted by the Swiss Federal Statistical Office for the federal census of 1990 (18). It differs from the International Standard Classification of Occupations (19), which is defined according to occupations, rather than according to economic sectors. Original occupational codes were converted to the ASCR codes, using a conversion key.

Table 1. Cancer registry characteristics and representativity. (ASCR = The Association of Swiss Cancer Registries)

Registry	Year of creation	Population covered ^a (per thousand)		Cases per year ^{b,c}	Cases registered on death certificate only ^c (%)	Cases registered on clinical status only ^c (%)	Population density ^a (inhabitants/km ²)	Sector of activity ^{a,d} (%)		
		N	%					Primary	Secondary	Tertiary
Basel	1981	448	6.5	1294	0.0	1.1	963	1.5	32.2	66.4
Geneva	1970	379	5.5	1166	1.7	5.0	1343	0.9	16.9	82.3
St Gall - Appenzell	1980	494	7.2	1311	0.7	5.1	203	5.6	39.3	55.1
Vaud	1972	601	8.7	1812	1.8	4.9	187	4.6	25.8	69.6
Zurich	1980	1179	17.2	2688 ^e	0.2	4.1	682	2.0	27.0	71.0
All five registries	-	3101	45.1	8271	0.7	4.2	377	2.8	28.0	69.2
All of Switzerland	-	6874	100	18200 ^f	-	-	167	4.3	31.7	64.1

^a Data from the 1990 federal census.

^b Mean number of cancers per year among males.

^c Data from the ASCR (1990–1994 period for Basel, Geneva, St Gall-Appenzell, and Vaud and 1989–1993 period for Zurich). See the Materials and Methods section.

^d Full-time active population.

^e The registry of Zurich does not systematically register squamous- and basal-cell carcinomas of the skin.

^f Estimation of the national incidence established by ASCR (1990–1994 period, males).

Table 2. Information on occupation provided by the cancer registries and the selection of the population. (ASCR = The Association of Swiss Cancer Registries)

Registry	First year of coding for occupations	Main sources of information	Definition of occupation	Classification used	Selection of data		Unclassifiable occupations ^{a,b} (%)	Unknown occupations ^{a,c} (%)
					Period	Age (years)		
Basel	1981	Register of population ^d , telephone book	Present or last occupation ^e	Federal census ^f	1981–1993	≥ 25	8.6	8.6
Geneva	1980	Register of population ^d , hospital records	Last occupation	Vital statistics ^g	1981–1993	≥ 25	8.5	0.5
St Gall - Appenzell	1989	Register of population ^d , telephone book	Present or last occupation ^e	Federal census ^f	1989–1992	25–64	5.1	23.2
Vaud	1989	Hospital records	Present occupation	Federal census ^f	1989–1993	25–64	7.1	23.1
Zurich	1980	Hospital records, register of population ^d , death certificates, telephone book	Main or best specified occupation	Vital statistics ^g	1980–1989	≥ 25	4.5	4.7

^a In the selected population under study.

^b Occupations roughly specified, unclassifiable, or not frequent enough to be analyzed separately (ASCR code 21, see appendix 1).

^c Unknown occupations, unemployed persons and retired persons (ASCR code 22, see appendix 1).

^d Cantonal or communal registry offices in charge of population files.

^e Depending on sources used.

^f Classification of the federal census performed in 1980, elaborated by the Swiss Federal Statistical Office (17).

^g Classification of the vital statistics elaborated by the Swiss Federal Statistical Office (16).

Table 3. Distribution of incident cancer cases by site and cancer registry.

Site ^a	Basel		Geneva		St Gall - Appenzell		Vaud		Zurich ^b		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Lip	28	0.2	47	0.4	6	0.4	3	0.1	115	0.5	199	0.3
Oral cavity & oropharynx	310	2.0	477	3.6	53	3.2	182	5.5	478	2.0	1500	2.6
Salivary gland	22	0.1	26	0.2	3	0.2	7	0.2	38	0.2	96	0.2
Nasopharynx	12	0.1	18	0.1	6	0.4	7	0.2	32	0.1	75	0.1
Other pharynx	87	0.5	142	1.1	18	1.1	92	2.8	145	0.6	484	0.8
Esophagus	188	1.2	235	1.8	34	2.1	90	2.7	270	1.1	817	1.4
Stomach	640	4.0	443	3.3	63	3.9	93	2.8	1161	4.9	2400	4.1
Cardia	129	0.8	109	0.8	17	1.0	26	0.8	335	1.4	616	1.1
Small intestine	124	0.8	33	0.2	7	0.4	11	0.3	101	0.4	276	0.5
Colon	1027	6.5	844	6.3	61	3.7	161	4.8	1673	7.0	3766	6.5
Rectum	725	4.6	449	3.3	63	3.9	95	2.9	1209	5.1	2541	4.4
Liver	273	1.7	335	2.5	36	2.2	54	1.6	474	2.0	1172	2.0
Gallbladder & biliary tract	82	0.5	81	0.6	8	0.5	15	0.5	183	0.8	369	0.6
Gallbladder	43	0.3	25	0.2	3	0.2	4	0.1	57	0.2	132	0.2
Extrahepatic bile duct	39	0.2	56	0.4	5	0.3	11	0.3	126	0.5	237	0.4
Pancreas	275	1.7	304	2.3	44	2.7	74	2.2	650	2.7	1347	2.3
Peritoneum	24	0.2	15	0.1	2	0.1	11	0.3	48	0.2	100	0.2
Nose, sinuses, etc	33	0.2	24	0.2	4	0.2	6	0.2	58	0.2	125	0.2
Larynx	187	1.2	263	2.0	32	2.0	68	2.0	292	1.2	842	1.4
Lung	2351	14.8	1909	14.2	258	15.8	514	15.4	4074	17.1	9106	15.7
Epidermoid	1007	6.3	856	6.4	95	5.8	170	5.1	1846	7.7	3974	6.8
Adenocarcinoma	601	3.8	446	3.3	72	4.4	136	4.1	865	3.6	2120	3.6
Small-cell carcinoma	484	3.0	307	2.3	59	3.6	105	3.2	739	3.1	1694	2.9
Giant-cell carcinoma	233	1.5	217	1.6	28	1.7	85	2.6	423	1.8	986	1.7
Pleura	80	0.5	37	0.3	15	0.9	12	0.4	166	0.7	310	0.5
Mesothelioma	71	0.4	25	0.2	13	0.8	8	0.2	98	0.4	215	0.4
Bone & cartilage	23	0.1	15	0.1	6	0.4	9	0.3	51	0.2	104	0.2
Soft tissue	60	0.4	85	0.6	23	1.4	17	0.5	169	0.7	354	0.6
Kaposi's sarcoma	23	0.1	91	0.7	10	0.6	51	1.5	113	0.5	288	0.5
Melanoma of the skin	371	2.3	295	2.2	52	3.2	139	4.2	684	2.9	1541	2.7
Head & neck	71	0.4	46	0.3	3	0.2	13	0.4	119	0.5	252	0.4
Trunk	163	1.0	147	1.1	22	1.3	70	2.1	293	1.2	695	1.2
Arm	83	0.5	53	0.4	17	1.0	31	0.9	154	0.6	338	0.6
Leg	54	0.3	41	0.3	9	0.6	24	0.7	118	0.5	246	0.4
Squamous-cell carcinoma	841	5.3	728	5.4	30	1.8	152	4.6	720	3.0	2471	4.3
Basal-cell carcinoma	2891	18.2	2498	18.6	306	18.7	624	18.7	197	0.8	6516	11.2
Breast	24	0.2	16	0.1	3	0.2	7	0.2	46	0.2	96	0.2
Prostate	2476	15.6	1606	12.0	127	7.8	156	4.7	4761	20.2	9126	15.7
Testis	240	1.5	171	1.3	105	6.4	127	3.8	469	2.0	1112	1.9
Other male genital	43	0.3	38	0.3	5	0.3	12	0.4	102	0.4	200	0.3
Urinary bladder	556	3.5	607	4.5	34	2.1	91	2.7	1726	7.2	3014	5.2
Kidney, Urinary tract	455	2.9	334	2.5	44	2.7	76	2.3	773	3.2	1682	2.9
Kidney	375	2.4	248	1.8	40	2.4	69	2.1	624	2.6	1356	2.3
Renal pelvis	80	0.5	86	0.6	4	0.2	7	0.2	149	0.6	326	0.6
Eye & lacrimal gland	32	0.2	18	0.1	2	0.1	7	0.2	50	0.2	109	0.2
Brain & nervous system	222	1.4	170	1.3	31	1.9	69	2.1	387	1.6	879	1.5
Thyroid gland	87	0.5	40	0.3	11	0.7	19	0.6	163	0.7	320	0.6
Other endocrine glands	25	0.2	14	0.1	3	0.2	2	0.1	26	0.1	70	0.1
Non-Hodgkin's lymphoma	300	1.9	234	1.7	27	1.7	97	2.9	467	2.0	1125	1.9
Hodgkin's disease	67	0.4	68	0.5	17	1.0	23	0.7	170	0.7	345	0.6
Multiple myeloma	107	0.7	123	0.9	21	1.3	20	0.6	264	1.1	535	0.9
Leukemia	316	2.0	295	2.2	40	2.4	66	2.0	605	2.5	1322	2.3
Myeloid leukemia	121	0.8	134	1.0	17	1.0	37	1.1	234	1.0	543	0.9
Lymphoid leukemia	149	0.9	134	1.0	16	1.0	18	0.5	251	1.1	568	1.0
Chronic lymphatic leukemia	134	0.8	119	0.9	14	0.9	13	0.4	234	1.0	514	0.9
Acute leukemia	94	0.6	90	0.7	13	0.8	23	0.7	168	0.7	388	0.7
Nonacute leukemia	212	1.3	203	1.5	26	1.6	43	1.3	434	1.8	918	1.6
Primary site uncertain	226	1.4	304	2.3	23	1.4	62	1.9	647	2.7	1262	2.2
All sites	15897	.	13426	.	1633	.	3331	.	23847	.	58134	.

^a According to the International Classification of Diseases for Oncology.^b The registry of Zurich does not systematically register squamous- and basal-cell carcinomas of the skin.

The ASCR classification and detailed occupational descriptions are available in appendix 1.

The distribution of cancer cases by occupation and cancer registry is provided in table 4. The most frequent occupational groups in the study sample were trade and commerce, administration and computers (23.6%), followed by metallurgy and electrotechnology (12.5%) and transport and telecommunication (8.0%). Agriculture and animal producers represented less than 5% of the occupations among men.

Nonexploitable occupations

Two different groups of nonexploitable occupations were considered separately. The first, "unclassifiable or not classified elsewhere" (appendix 1, ASCR code 21), referred to occupations which could not be classified in the ASCR codes and which were not frequent enough to be analyzed separately (mountain guides, professional sportsmen, etc), as well as occupations imprecisely specified (seasonal workers, employees, or workers not further specified). The second group, "unemployed or unknown" (appendix 1, ASCR code 22) included students, unknown, unemployed and retired persons, persons of private means, housewives, and children under 18 years of age. Table 2 presents the percentage of cases with "nonexploitable" occupations by cancer registries. If the percentage of "occupations not classified elsewhere" remained relatively constant (between 4.5 and 8.6), the percentage of unknown occupations differed greatly among the registries. Despite the use of several sources of information at the time of incidence, occupation remains unknown in 23% of the records from St Gall-Appenzell and Vaud. In these two cantons, information on occupation is often found postmortem by individual linkage with mortality statistics. Such additional information at the time of death was not available in this study. In Geneva, on the contrary, this percentage was lower than 1%, mainly because the cantonal registry of the resident population records the occupation systematically. The resulting effect of missing data is discussed further in the section on the limitations and interpretation beginning on page 13.

Socioeconomic status

The 87 occupational subgroups were subsequently carefully regrouped in order to create a seven-level indicator of socioeconomic status. This classification is mainly based on the social classes of the British Registrar General (20, 21). Level I includes professionals, level II is formed from executives, managers, engineers, administrators and managerial workers, level III is comprised of nonmanual employees and administrative staff,

level IV contains manual workers and employees in commerce and trade, level V includes skilled or specialized workers, level VI is made up of unskilled manual workers and domestic workers, and level VII represents occupations not otherwise classified and persons unemployed or unknown. Farmers and agricultural workers were included in level V (appendix 2).

Cancer sites

Both the morphology and primary site of the tumor were coded according to the International Classification of Diseases for Oncology (ICD-O) (22). The tumor was the unit of analysis. Therefore, multiple tumors (about 3% of all cases) were considered as separate events. All primary sites were individually analyzed. Leukemias were further divided into subcategories because the subtypes are considered to have different etiologies, for instance, lymphoid leukemia (ICD-O M code 982), chronic lymphoid leukemia (ICD-O M code 9823), myeloid leukemia (ICD-O M code 986), and acute leukemia (ICD-O M codes 9801, 9821, 9841, 9861, 9891). For lung cancer, specific histology codes were grouped into cell types according to the specifications of the World Health Organization for the typing of lung tumors (23), which, even if contestable for some histological types, permits the differentiation of squamous cell (ICD-O M codes 8070–8074), small cell (ICD-O M codes 8041–8043), adeno (ICD-O M codes 8140, 8230, 8250, 8260, 8480, 8481, and 8550), and large cell (ICD-O M codes 8012, 8031) carcinomas. For the stomach (cardia versus other), the biliary system (gallbladder versus bile ducts), and the kidney (parenchyma versus pelvis), additional analyses by these "subsites" were performed. Squamous-cell carcinoma and adenocarcinoma of the esophagus were also distinguished. Tumors of the skin were also analyzed by histology type and sublocalization. Extra-nodal lymphomas were classified according to their target organs. Pleural tumors that were histologically defined as mesotheliomas were also analyzed as a separate group. Kaposi's sarcoma was considered a separate category, independently of the site of origin.

Other variables

Additional variables known or suspected to modify cancer risks were considered confounders. Age was grouped into six categories (25–34, 35–44, 45–54, 55–64, 65–74, ≥ 75 years), marital status into three (single, other, not specified) and period of diagnosis into three

Table 4. Distribution of incident cancer cases by occupation and cancer registry. (ASCR = The Association of Swiss Cancer Registries)

ASCR code	Occupation ^a	Basel		Geneva		St Gall - Appenzell		Vaud		Zurich		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
01	AGRICULTURE & ANIMAL PRODUCERS	436	2.7	418	3.1	121	7.4	160	4.8	1326	5.6	2461	4.2
011	Farmers & animal producers	218	1.4	155	1.2	102	6.2	81	2.4	837	3.5	1393	2.4
012	Viniculturists	1	0.0	17	0.1	—	0.0	27	0.8	13	0.1	58	0.1
013	Horticulturists & related occupations	152	1.0	164	1.2	6	0.4	41	1.2	362	1.5	725	1.2
019	Other occupations in agriculture & stockbreeding	65	0.4	82	0.6	13	0.8	11	0.3	114	0.5	285	0.5
02	FOOD, BEVERAGE & TOBACCO INDUSTRIES	316	2.0	289	2.2	39	2.4	47	1.4	618	2.6	1309	2.3
021	Bakers & related occupations	123	0.8	96	0.7	11	0.7	15	0.5	279	1.2	524	0.9
022	Cheesemakers & related occupations	21	0.1	25	0.2	4	0.2	3	0.1	63	0.3	116	0.2
023	Butchers & related occupations	150	0.9	98	0.7	18	1.1	18	0.5	215	0.9	499	0.9
024	Other related food & beverage preparers	22	0.1	54	0.4	6	0.4	10	0.3	59	0.2	151	0.3
025	Occupations in tobacco production	—	0.0	16	0.1	—	0.0	1	0.0	2	0.0	19	0.0
03	TEXTILE, LEATHER & FUR INDUSTRIES	155	1.0	135	1.0	29	1.8	20	0.6	421	1.8	760	1.3
031	Textile-related trades workers	24	0.2	7	0.1	15	0.9	4	0.1	104	0.4	154	0.3
032	Tailors & related occupations	57	0.4	72	0.5	7	0.4	6	0.2	163	0.7	305	0.5
033	Occupations in the pelt, leather & fur industries	74	0.5	56	0.4	7	0.4	10	0.3	154	0.6	301	0.5
04	CONSTRUCTION & RELATED OCCUPATIONS	953	6.0	676	5.0	91	5.6	146	4.4	1849	7.8	3715	6.4
041	Bricklayers, stonemasons, tilers & related occupations	381	2.4	292	2.2	47	2.9	72	2.2	682	2.9	1474	2.5
042	Roofers	18	0.1	11	0.1	3	0.2	—	0.0	50	0.2	82	0.1
043	Plasterers & painters	381	2.4	245	1.8	19	1.2	50	1.5	584	2.4	1279	2.2
044	Other painters & related occupations	21	0.1	26	0.2	2	0.1	3	0.1	56	0.2	108	0.2
049	Other occupations in construction & related trades	152	1.0	102	0.8	20	1.2	21	0.6	477	2.0	772	1.3
05	STONE, EARTH & GLASS INDUSTRIES	42	0.3	60	0.4	1	0.1	10	0.3	223	0.9	336	0.6
051	Stone & earth trades workers	26	0.2	29	0.2	1	0.1	7	0.2	120	0.5	183	0.3
052	Glassmakers & related trades workers	8	0.1	17	0.1	—	0.0	2	0.1	30	0.1	57	0.1
059	Miners, quarriers & related occupations	8	0.1	14	0.1	—	0.0	1	0.0	73	0.3	96	0.2
06	METALLURGY & ELECTROTECHNOLOGY	1596	10.0	1548	11.5	185	11.3	314	9.4	3647	15.3	7290	12.5
061	Foundry workers	5	0.0	12	0.1	—	0.0	3	0.1	355	1.5	375	0.6
062	Turners & related occupations	51	0.3	26	0.2	9	0.6	9	0.3	711	3.0	806	1.4
063	Mechanics	443	2.8	572	4.3	57	3.5	120	3.6	1011	4.2	2203	3.8
064	Electricians	220	1.4	168	1.3	25	1.5	54	1.6	640	2.7	1107	1.9
065	Watchmakers	51	0.3	126	0.9	3	0.2	12	0.4	26	0.1	218	0.4
066	Watch industry & related occupations	15	0.1	34	0.3	—	0.0	—	0.0	1	0.0	50	0.1
067	Pump attendants	14	0.1	4	0.0	2	0.1	—	0.0	15	0.1	35	0.1
069	Metallurgy, electrotechnology & related occupations	797	5.0	606	4.5	89	5.5	116	3.5	888	3.7	2496	4.3
07	WOOD, CORK & PAPER INDUSTRIES	423	2.7	276	2.1	50	3.1	44	1.3	704	3.0	1497	2.6
071	Carpenters	64	0.4	19	0.1	9	0.6	9	0.3	119	0.5	220	0.4
072	Joiners, cabinetmakers & related occupations	327	2.1	216	1.6	34	2.1	32	1.0	490	2.1	1099	1.9
073	Occupations related to the wood & cork industry	32	0.2	33	0.2	7	0.4	2	0.1	67	0.3	141	0.2
074	Occupations related to the paper industry	—	0.0	8	0.1	—	0.0	1	0.0	28	0.1	37	0.1
08	GRAPHIC ARTS	215	1.4	192	1.4	3	0.2	37	1.1	347	1.5	794	1.4
081	Typographers	74	0.5	77	0.6	—	0.0	8	0.2	53	0.2	212	0.4
089	Other occupations related to printing & graphic arts	141	0.9	115	0.9	3	0.2	29	0.9	294	1.2	582	1.0
09	CHEMICAL & PLASTICS INDUSTRIES	414	2.6	23	0.2	1	0.1	7	0.2	82	0.3	527	0.9
091	Chemical workers	400	2.5	18	0.1	—	0.0	7	0.2	38	0.2	463	0.8
092	Gasworks & refinery workers	3	0.0	4	0.0	—	0.0	—	0.0	19	0.1	26	0.0
093	Plastics & rubber workers	11	0.1	1	0.0	1	0.1	—	0.0	25	0.1	38	0.1
10	TECHNICAL PROFESSIONS & TRADES	1561	9.8	890	6.6	125	7.7	292	8.8	2361	9.9	5229	9.0
101	Architects	125	0.8	95	0.7	7	0.4	21	0.6	222	0.9	470	0.8
102	Chemical engineers	141	0.9	—	0.0	—	0.0	5	0.2	—	0.0	146	0.3
103.1	Agronomists & related occupations	2	0.0	11	0.1	1	0.1	4	0.1	41	0.2	59	0.1
103.9	Other engineers	245	1.5	413	3.1	38	2.3	100	3.0	944	4.0	1740	3.0
104	Technicians & foremen	402	2.5	106	0.8	27	1.7	90	2.7	418	1.8	1043	1.8
105	Draftspersons	82	0.5	68	0.5	11	0.7	18	0.5	103	0.4	282	0.5
106	Laboratory assistants	239	1.5	34	0.3	6	0.4	3	0.1	38	0.2	320	0.6
107	Mechanics & related occupations	212	1.3	16	0.1	20	1.2	39	1.2	182	0.8	469	0.8
109	Other related technical occupations	113	0.7	147	1.1	15	0.9	12	0.4	413	1.7	700	1.2

(continued)

Table 4. Continued.

ASCR code	Occupation ^a	Basel		Geneva		St Gall - Appenzell		Vaud		Zurich		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
11	TRADE, ADMINISTRATION & COMPUTERS	3747	23.6	4247	31.6	248	15.2	617	18.5	4839	20.3	13698	23.6
111	Entrepreneurs & managers	941	5.9	1056	7.9	66	4.0	141	4.2	1915	8.0	4119	7.1
112	Clerks	1817	11.4	2222	16.5	87	5.3	248	7.4	2108	8.8	6482	11.2
113	Computing occupations	16	0.1	28	0.2	1	0.1	8	0.2	62	0.3	115	0.2
114	Pharmaceutical assistants	26	0.2	18	0.1	1	0.1	1	0.0	32	0.1	78	0.1
115	Salespersons & representatives	838	5.3	823	6.1	71	4.3	169	5.1	685	2.9	2586	4.4
116	Chartered accountants & related occupations	109	0.7	100	0.7	22	1.3	50	1.5	37	0.2	318	0.5
12	TRANSPORT & TELECOMMUNICATIONS	1246	7.8	1018	7.6	89	5.5	202	6.1	2077	8.7	4632	8.0
121.1	Locomotive engineers	60	0.4	10	0.1	4	0.2	3	0.1	103	0.4	180	0.3
121.2	Other occupations related to railways	365	2.3	104	0.8	22	1.3	42	1.3	547	2.3	1080	1.9
123	Drivers	444	2.8	475	3.5	34	2.1	90	2.7	753	3.2	1796	3.1
124	Aircraft pilots	2	0.0	2	0.0	—	0.0	3	0.1	14	0.1	21	0.0
125	Other occupations related to transport	201	1.3	226	1.7	10	0.6	17	0.5	364	1.5	818	1.4
126	Post & telecommunications	174	1.1	201	1.5	19	1.2	47	1.4	296	1.2	737	1.3
13	LAW & SECURITY OCCUPATIONS	324	2.0	288	2.1	12	0.7	55	1.7	527	2.2	1206	2.1
131	Legal experts & related occupations	143	0.9	119	0.9	6	0.4	23	0.7	219	0.9	510	0.9
132	Police officers & related occupations	181	1.1	169	1.3	6	0.4	32	1.0	308	1.3	696	1.2
14	MEDIA & RELATED OCCUPATIONS	60	0.4	134	1.0	10	0.6	30	0.9	131	0.5	365	0.6
141	Editors, librarians & related occupations	54	0.3	134	1.0	6	0.4	30	0.9	131	0.5	355	0.6
142	Cinema operators	6	0.0	—	0.0	4	0.2	—	0.0	—	0.0	10	0.0
15	ARTISTIC OCCUPATIONS	203	1.3	301	2.2	16	1.0	35	1.1	361	1.5	916	1.6
151	Jewelers & related occupations	11	0.1	88	0.7	2	0.1	6	0.2	26	0.1	133	0.2
152	Artists & related occupations	192	1.2	213	1.6	14	0.9	29	0.9	335	1.4	783	1.3
16	HOTEL & CATERING OCCUPATIONS	250	1.6	447	3.3	41	2.5	76	2.3	584	2.4	1398	2.4
161	Hotel & restaurant managers	119	0.7	178	1.3	22	1.3	22	0.7	271	1.1	612	1.1
162	Cooks	70	0.4	63	0.5	13	0.8	19	0.6	134	0.6	299	0.5
163	Catering & hotel employees	57	0.4	102	0.8	6	0.4	27	0.8	113	0.5	305	0.5
164	Domestic workers & related occupations	4	0.0	104	0.8	—	0.0	8	0.2	66	0.3	182	0.3
17	CLEANING & PERSONAL SERVICES	285	1.8	468	3.5	24	1.5	49	1.5	458	1.9	1284	2.2
171	Chimney sweeps	11	0.1	6	0.0	1	0.1	—	0.0	29	0.1	47	0.1
172	Occupations related to laundering, dyeing & dry cleaning	17	0.1	14	0.1	1	0.1	—	0.0	—	0.0	32	0.1
173	Other occupations related to cleaning	146	0.9	335	2.5	12	0.7	36	1.1	286	1.2	815	1.4
174	Occupations related to roads department & undertakers	11	0.1	46	0.3	2	0.1	4	0.1	10	0.0	73	0.1
175	Hairdressers	98	0.6	65	0.5	5	0.3	9	0.3	127	0.5	304	0.5
176	Other occupations related to body care	2	0.0	2	0.0	3	0.2	—	0.0	6	0.0	13	0.0
18	HEALTH CARE OCCUPATIONS	322	2.0	330	2.5	34	2.1	73	2.2	449	1.9	1208	2.1
181	Physicians	151	0.9	151	1.1	13	0.8	27	0.8	141	0.6	483	0.8
182	Dentists, veterinarians & pharmacists	59	0.4	79	0.6	8	0.5	15	0.5	88	0.4	249	0.4
183	Nurses & related occupations	55	0.3	31	0.2	5	0.3	10	0.3	52	0.2	153	0.3
184	Medical assistants	4	0.0	21	0.2	—	0.0	2	0.1	27	0.1	54	0.1
185	Radiology assistants	1	0.0	2	0.0	—	0.0	—	0.0	—	0.0	3	0.0
186	Other occupations related to health	52	0.3	46	0.3	8	0.5	19	0.6	141	0.6	266	0.5
19	SOCIAL WORK & TEACHING PROFESSIONS	317	2.0	296	2.2	39	2.4	70	2.1	426	1.8	1148	2.0
191	Professors & teachers	270	1.7	238	1.8	37	2.3	61	1.8	333	1.4	939	1.6
192	Religious professionals	29	0.2	43	0.3	2	0.1	7	0.2	74	0.3	155	0.3
193	Social workers & related occupations	18	0.1	15	0.1	—	0.0	2	0.1	19	0.1	54	0.1
20	SCIENCE PROFESSIONS	299	1.9	180	1.3	12	0.7	43	1.3	232	1.0	766	1.3
201	Chemists	121	0.8	54	0.4	3	0.2	3	0.1	62	0.3	243	0.4
202	Physicists, biologists & related occupations	28	0.2	35	0.3	1	0.1	8	0.2	34	0.1	106	0.2
209	Other scientific occupations	150	0.9	91	0.7	8	0.5	32	1.0	136	0.6	417	0.7
21	NOT CLASSIFIED ELSEWHERE	1373	8.6	1142	8.5	84	5.1	236	7.1	1064	4.5	3899	6.7
22	UNEMPLOYED OR UNKNOWN OCCUPATIONS	1360	8.6	68	0.5	379	23.2	768	23.1	1121	4.7	3696	6.4
ALL OCCUPATIONS		15897	100	13426	100	1633	100	3331	100	23847	100	58134	100

^a See appendix 1.

(1980–1983, 1984–1988, 1989–1993). Nationality was grouped into four categories (Swiss, southern Europe, other countries, not specified). The registry of St Gall-Appenzell did not collect any information on nationality. The variable “level of urbanization” was based on the area of residence. The concept of urbanization was coded into three levels, regrouping the basic units defined by the Federal Office of Statistics (24). Urban area included agglomerations of adjacent communes regrouping a minimum of 20 000 inhabitants and towns of more than 10 000 inhabitants, suburban areas included other agglomerations and towns, and rural areas included villages with less than 10 000 inhabitants that are not part of an agglomeration. Two items, the histological verification of the tumor (yes, no) and the death-certificate-only cases (no, yes) that could affect the accuracy of the data were also considered.

Statistical methods

Estimation of cancer risk by occupation

Because of the discordance in both occupational classification and occupational information, and the sources between census and incident cases, rates could not be calculated. The analyses were based on incident cases only, using the case-referent approach, with which the cancer of interest provides the cases and all other cancers serve as referents (14, 25, 26). For each cancer site, odds ratios by occupation in reference to all other occupations were estimated in a logistic regression (27) using the GLIM (general linear interactive modelling) statistical package (28). Odds ratios were adjusted for registry (Basel, Geneva, St Gall-Appenzell, Vaud and Zurich), age at occurrence, marital status, calendar

period, degree of urbanization, and nationality, as well as for the dichotomous variables “histological verification” and “death certificate only”. For rare cancer sites, 300 cases in the series were regrouped into fewer categories with adjustment for the variables age and nationality (age as 25–44, 45–54, 55–64, 65–74, and ≥ 75 years and nationality as Swiss or other). The statistical significance of each variable was assessed by likelihood ratios of the model with and without the variable of interest.

Estimation of cancer risk by socioeconomic status

The variation of cancer risks by socioeconomic status was also investigated. The socioeconomic indicator (seven levels, see the Materials and Methods section and appendix 2) was recoded into socioeconomic status of five levels by combining (i) professionals and executives (levels I and II), (ii) nonmanual employees (level III), (iii) manual employees (level IV), (iv) skilled workers, farmers included (level V), (v) unskilled workers (level VI). Individuals with unknown socioeconomic status were excluded (level VII). The “nonmanual employee” category, which was the most frequent, was used as a reference category. Risks by socioeconomic status were estimated with the aid of multivariate analyses using the same adjustment variables as for the occupational risk assessment.

Adjustment for socioeconomic status

To assess the residual occupational variation after adjustment for socioeconomic status and to search for clues of occupation-specific factors, we estimated the occupation-specific odds ratios (OR) with and without adjustment for socioeconomic status.

The study population and, more importantly, the method of assessing occupational cancer risks have several inherent limitations.

Quality of cancer registration data

The Swiss cancer registries are highly complete and accurate, as attested by the low percentage (<5%) of cases discovered by death certificate only (29). However, it is well known worldwide that some hematological malignancies and also basal-cell skin carcinoma are prone to underregistration (for an example see reference 30) that could be large enough to cause bias in the occupational and socioeconomic patterns of cancer sites.

Validity of occupational records

The main limitation of the study lies in the quality of information on occupation. Even if the accuracy of the

occupational characterization routinely performed by the cancer registries has never been evaluated, it is inevitably lower than occupational information obtained in specialized epidemiologic studies on occupation. As stated in the Materials section (see also table 2), registries differ as to their sources of information or the definition of occupations and their codification. In order to investigate the heterogeneity of the results between registries, interaction tests were performed for the occupations and cancer sites listed in table 5. Interaction terms involving occupation and registry were introduced into the model (27). None of the interaction tests were significant. However, due to the small number of cases per occupation and registry, the power of these tests was not always sufficient. For several cancer sites defined a priori, additional analyses were performed after exclusion of the registries with the greatest proportion of unknown occupations (ie, Vaud and St Gall). The occupational patterns remained unchanged.

"Dilution" of risk occurs when different occupations are regrouped in the same category. For example, the

Table 5. Main expected associations between the ASCR occupational groups and cancer, a priori established from the literature. (ASCR = The Association of Swiss Cancer Registries)

ASCR code	Occupation ^a	Cancer site	Comments	Main references
04	Construction & related occupations	Pleura Pleura	Asbestos Asbestos	Monson, 1996 (47) Monson, 1996 (47)
05	Stone, earth & glass occupations	Pleura	Asbestos	Monson, 1996 (47)
06	Metallurgical & electro-technological occupations	Pleura	Asbestos	Monson, 1996 (47)
121.2	Railway-related workers	Pleura	Asbestos	Monson, 1996 (47)
07	Wood, cork & paper workers	Nose, sinuses	No specific agents established	Nylander & Dement, 1993 (52) Minder & Vader, 1987 (75)
071	Carpenters	Hodgkin's disease	No specific agents established	Nylander & Dement, 1993 (52) Minder & Vader, 1987 (75)
072	Joiners, cabinetmakers & related occupations	Hodgkin's disease	No specific agents established	Nylander, & Dement, 1993 (52) Minder & Vader, 1987 (75)
033	Occupations in pelt, leather & fur industries	Nose, sinuses, bladder	No specific agents established	Monson, 1996 (47)
01	Agriculture & animal producers	Lip, thyroid, lymphatic and hematopoietic	Ultraviolet radiation (lip), iodine deficiency in rural areas (thyroid), no specific agents established (lymphohematopoietic system)	Khuder, 1999 (40) Monson, 1996 (47) Levi et al, 1990 (134) Acquavella et al, 1998 (151)
01	Agriculture & animal producers	Soft-tissue sarcoma	Pesticides, more particularly, chlorophenoxy herbicides	Monson, 1996 (47) Hoar Zahm et al, 1996 (102)
013	Horticulturists & related occupations	Soft-tissue sarcoma	Pesticides, more particularly, chlorophenoxy herbicides	Monson, 1996 (47) Hoar Zahm et al, 1996 (102)

(continued)

Table 5. Continued.

ASCR code	Occupation ^a	Cancer site	Comments	Main references
061	Foundry workers	Lung	Dust, fumes	Monson, 1996 (47)
063	Mechanics	Lung, skin, esophagus	Engine exhaust fumes (lung, esophagus), mineral oils for mechanics only (esophagus, skin)	Monson, 1996 (47) Gubéran et al, 1992 (59) IARC, 1989 (162)
107	Machinists & related occupations	Lung, skin, esophagus	Engine exhaust fumes (lung, esophagus), mineral oils for mechanics only (esophagus, skin)	Monson, 1996 (47) Gubéran et al, 1992 (59) IARC, 1989 (162)
123	Drivers	Lung, skin, esophagus	Engine exhaust fumes (lung, esophagus), mineral oils for mechanics only (esophagus, skin)	Monson, 1996 (47) Gubéran et al, 1992 (59) IARC, 1989 (162)
171	Chimney sweeps	Lung, urinary bladder, skin	Polycyclic aromatic hydrocarbons	Monson, 1996 (47)
091	Chemical workers	Lymphatic and hematopoietic	General survey of different chemically exposed groups of workers with no specific chemicals a priori involved	Monson, 1996 (47)
102	Chemical engineers	Lymphatic and hematopoietic	General survey of different chemically exposed groups of workers with no specific chemicals a priori involved	Monson, 1996 (47)
106	Laboratory assistants	Lymphatic and hematopoietic	General survey of different chemically exposed groups of workers with no specific chemicals a priori involved	Monson, 1996 (47)
201	Chemists	Lymphatic and hematopoietic	General survey of different chemically exposed groups of workers with no specific chemicals a priori involved	Monson, 1996 (47)
023	Butchers & related occupations	Lymphatic and hematopoietic, lung	No specific agents established	Monson, 1996 (47) Gubéran et al, 1993 (139)
065	Watchmakers	Bone	Radium, mesothorium exposure of dial painters	Monson, 1996 (47)
151	Jewelers & related occupations	Bone	Radium, mesothorium exposure of dial painters	Monson, 1996 (47)
081	Typographers	Leukemia	Benzene exposure	Monson, 1996 (47)
033	Pelt, leather & fur workers (including shoemakers)	Leukemia	Benzene exposure	Monson, 1996 (47)
063	Mechanics	Leukemia	Low benzene exposure, controversy in the literature	Monson, 1996 (47) Linet & Cartwright, 1996 (143) Hotz & Lauwerys, 1997 (155)
067	Pump attendants	Leukemia	Low benzene exposure, controversy in the literature	Monson, 1996 (47) Linet & Cartwright, 1996 (143) Hotz & Lauwerys, 1997 (155)
123	Drivers	Leukemia	Low benzene exposure, controversy in the literature	Monson, 1996 (47) Linet & Cartwright, 1996 (143) Hotz & Lauwerys, 1997 (155)
121.1	Locomotive engineers	Leukemia	Low benzene exposure, controversy in the literature	Monson, 1996 (47) Linet & Cartwright, 1996 (143) Hotz & Lauwerys, 1997 (155)
043	Plasterers & painters	Lung, liver	No specific agents established, controversy in the literature	Monson, 1996 (47) IARC, 1989 (154)
191	Professors & teachers	Myeloma	No specific agents established, controversy in the literature	Herrinton et al, 1996 (142)
064	Electricians	Leukemia, brain	Electromagnetic fields, controversy in the literature	Preston-Martin & Mack, 1996 (132) Kheifets et al, 1995 (133) Linet & Cartwright, 1996 (143) Elwood, 1999 (144) Kheifets et al, 1997 (145)
121.1	Locomotive engineers	Leukemia	Low frequency magnetic fields, controversy in the literature	Ahlbom, 1988 (146) Balli-Antunes et al, 1990 (150)

^a See appendix 1.

ASCR occupational group for farmers and animal producers (ASCR code 011) is heterogeneous, as it not only includes agricultural laborers, but also farmers and farm managers. Other occupational groups, such as mechanics and occupations related to cleaning, represented a regrouping of various occupations. Finally, the ASCR codes did not allow us to distinguish between plasterers and painters or between dentists, veterinarians and pharmacists.

Bias related to the large proportion of cases with unclear occupations is not easy to quantify. Despite the important effort routinely undertaken by the registries to collect data on occupations, the fraction of records with missing or unclassifiable information remained high. In order to estimate the reliability of the occupational information, comparisons were made between the occupational distribution in this incidence data set and within the 1990 census for the same selection of area and age groups (table 6). The distribution in the data was relatively close to that of the general population.

The prevalence of missing occupational records by primary site, however, indicates that some selection had taken place. For example, an excess of unknown occupations (ASCR code 22) was observed for skin cancers other than melanoma, whereas a relative deficit was observed for mesothelioma (table 7), suggesting that occupational data were collected with more accuracy for cancers well known for occupational causes than for those with occupational exposure of lower interest.

Distinctive patterns were observed for unclassifiable occupations (ASCR code 21) in terms of higher risks of oral cavity, pharynx, esophagus, and lung cancers, and lower risks were found for cutaneous melanoma (table 7). Most of the cancer patterns of unclassifiable occupations reflect those of lower socioeconomic groups.

Socioeconomic classification

The attribution of socioeconomic status was based on occupation since no other indicator was available. The accuracy of this indicator thus depends on the accuracy of occupational information and, in particular, on its heterogeneity. For example, several occupational groups related to agriculture and hotel trades included both employers and employees, who could not be dissociated. Despite the fact that the socioeconomic indicator used can only be considered an approximate indicator of social status, its association with cancer risks is in agreement with that reported in the international literature.

Adjustment for socioeconomic status

Differences in cancer occurrence may be due to a combination of social (life-style) and economic factors

prevailing in an occupational group rather than to factors associated with the work environment. For an assessment of specific occupational risks, it is therefore necessary to consider odds ratios adjusted for socioeconomic status ($OR_{SES \text{ adjusted}}$). Such an adjustment corresponds to the use of a stratified analysis, in which cancer patterns in one occupation (eg, physicians) are compared with all other occupations having the same socioeconomic status. However, as the two methods provide nearly the same results, we chose to adjust for socioeconomic status for logistic reasons, rather than to make subgroup analyses.

Controlling confounding factors using socioeconomic information is at best incomplete because factors intermingle throughout the socioeconomic strata. Therefore, the risk adjusted for socioeconomic status, in comparison with the unadjusted risk, indicates the direction of correction, but some residual confounding always remains.

As an example, figure 1 shows a synopsis of the relative risks for the four cancer sites related to alcohol and tobacco, mouth, pharynx, larynx and esophagus, sorted by the sum of the relative risks of the four sites. For the occupations known to include a high prevalence of drinkers, these four risks are all elevated. Adjustment for social class eliminates the socially related component of these alcohol- and tobacco-related risks. Only hotel and construction workers continue to have elevated risks. On the other hand, people working in graphic and artistic branches, previously showing only hints of elevated risks, now clearly appear to have relatively high risks, well above the usual level of their social class. Parallel modifications of risk by adjustment for socioeconomic status are also seen for lung cancer.

Representativeness of the study population

As described in table 1, this study is limited to only five registries, and the studied area is not representative of the whole country. In particular, its population density is higher than the national average, and the primary economic sector is underrepresented. The occupational profile provided by the study is therefore not representative of that of Switzerland. Some specific industrial sectors, like the rubber industry, are concentrated in cantons that are not covered by cancer registration (eg, the canton of Uri). The lack of an expected association in our study could therefore reflect the absence of industries with relevant exposures in the studied areas.

Cases over 65 years of age were excluded in two cantons. This procedure may constitute a limitation when cancers occurring in old age or a long time after the suspected occupational exposure are studied.

Table 6. Comparison between occupational distribution^a in the incidence and 1990 census data.^b (ASCR = The Association of Swiss Cancer Registries)

ASCR code	Occupation	Incidence data	Census data
		%	%
01	AGRICULTURE & ANIMAL PRODUCERS	4.9	4.4
011	Farmers & animal producers	2.8	2.6
012	Viniculturists	0.1	0.2
013	Horticulturists & related occupations	1.4	1.0
019	Other occupations in agriculture & stockbreeding	0.6	0.6
02	FOOD, BEVERAGE & TOBACCO INDUSTRIES	2.6	1.4
021	Bakers & related occupations	1.0	0.6
022	Cheesemakers & related occupations	0.2	0.1
023	Butchers & related occupations	1.0	0.6
024	Other related food & beverage preparers	0.3	0.2
025	Occupations in tobacco production	0.0	0.0
03	TEXTILE, LEATHER & FUR INDUSTRIES	1.5	0.7
031	Textile-related trades workers	0.3	0.3
032	Tailors & related occupations	0.6	0.2
033	Occupations in the pelt, leather & fur industries	0.6	0.3
04	CONSTRUCTION & RELATED OCCUPATIONS	7.4	6.9
041	Bricklayers, stonemasons, tilers & related occupations	2.9	3.6
042	Roofers	0.2	0.2
043	Plasterers & painters	2.5	0.4
044	Other painters & related occupations	0.2	1.7
049	Other occupations in construction & related trades	1.5	1.1
05	STONE, EARTH & GLASS INDUSTRIES	0.7	0.3
051	Stone & earth trades workers	0.4	0.0
052	Glassmakers & related trades workers	0.1	0.1
059	Miners, quarriers & related occupations	0.2	0.1
06	METALLURGY & ELECTROTECHNOLOGY	14.4	12.7
061	Foundry workers	0.7	0.1
062	Turners & related occupations	1.6	0.7
063	Mechanics	4.4	3.8
064	Electricians	2.2	1.8
065	Watchmakers	0.4	0.1
066	Watch industry & related occupations	0.1	0.0
067	Pump attendants	0.1	0.1
069	Metallurgy, electrotechnology & related occupations	4.9	5.9
07	WOOD, CORK & PAPER INDUSTRIES	3.0	2.2
071	Carpenters	0.4	0.4
072	Joiners, cabinetmakers & related occupations	2.2	1.6
073	Occupations related to the wood & cork industry	0.3	0.2
074	Occupations related to the paper industry	0.1	0.1
08	GRAPHIC ARTS	1.6	1.2
081	Typographers	0.4	0.3
089	Other occupations related to printing & graphic arts	1.2	1.0
09	CHEMICAL & PLASTICS INDUSTRIES	1.0	0.4
091	Chemical workers	0.9	0.1
092	Gasworks & refinery workers	0.1	0.3
093	Plastics & rubber workers	0.1	0.1
10	TECHNICAL PROFESSIONS & TRADES	10.3	10.6
101	Architects	0.9	1.0
102	Chemical engineers	0.3	0.0
103.1	Agronomists & related occupations	0.1	2.7
103.9	Other engineers	3.4	0.1
104	Technicians & foremen	2.1	3.7

Table 6. Continued.

ASCR code	Occupation	Incidence data	Census data
		%	%
105	Draftspersons	0.6	0.8
106	Laboratory assistants	0.6	0.6
107	Mechanics & related occupations	0.9	1.8
109	Other related technical occupations	1.4	0.0
11	TRADE, ADMINISTRATION & COMPUTERS	27.1	31.5
111	Entrepreneurs & managers	8.2	7.0
112	Clerks	12.8	11.7
113	Computing occupations	0.2	2.5
114	Pharmaceutical assistants	0.2	0.1
115	Salespersons & representatives	5.1	6.7
116	Chartered accountants & related occupations	0.6	3.5
12	TRANSPORT & TELECOMMUNICATIONS	9.2	8.0
121.1	Locomotive engineers	0.4	0.3
121.2	Other occupations related to railways	2.1	0.5
123	Drivers	3.6	3.0
124	Aircraft pilots	0.0	0.2
125	Other occupations related to transport	1.6	1.9
126	Post & telecommunications	1.5	1.4
13	LAW & SECURITY OCCUPATIONS	2.4	2.7
131	Legal experts & related occupations	1.0	0.7
132	Police officers & related occupations	1.4	2.0
14	MEDIA & RELATED OCCUPATIONS	0.7	1.1
141	Editors, librarians & related occupations	0.7	0.7
142	Cinema operators	0.0	0.3
15	ARTISTIC OCCUPATIONS	1.8	1.7
151	Jewelers & related occupations	0.3	0.1
152	Artists & related occupations	1.5	1.5
16	HOTEL & CATERING OCCUPATIONS	2.8	3.6
161	Hotel & restaurant managers	1.2	1.0
162	Cooks	0.6	1.6
163	Catering & hotel employees	0.6	0.9
164	Domestic workers & related occupations	0.4	0.2
17	CLEANING & PERSONAL SERVICES	2.5	2.1
171	Chimney sweeps	0.1	0.1
172	Occupations related to laundering, dyeing & dry cleaning	0.1	0.0
173	Other occupations related to cleaning	1.6	1.5
174	Occupations related to roads department & undertakers	0.1	0.2
175	Hairdressers	0.6	0.3
176	Other occupations related to body care	0.0	0.0
18	HEALTH CARE OCCUPATIONS	2.4	2.8
181	Physicians	1.0	1.2
182	Dentists, veterinarians & pharmacists	0.5	0.4
183	Nurses & related occupations	0.3	0.5
184	Medical assistants	0.1	0.0
185	Radiology assistants	0.0	0.0
186	Other occupations related to health	0.5	0.7
19	SOCIAL WORK & TEACHING PROFESSIONS	2.3	4.3
191	Professors & teachers	1.9	3.8
192	Religious professionals	0.3	0.3
193	Social workers & related occupations	0.1	0.2
20	SCIENCE PROFESSIONS	1.5	1.3
201	Chemists	0.5	0.4
202	Physicists, biologists & related occupations	0.2	0.2
209	Other scientific occupations	0.8	0.7

^a After exclusion of unclassifiable occupations.^b For the same selection of area and age group.

Table 7. Distribution of incident cases and the odds ratios^a for cancer according to occupations not elsewhere classified^b or unknown^c. (ASCR = The Association of Swiss Cancer Registries, OR = odds ratio, 95% CI = 95% confidence interval))

Site ^d	Total number	Occupations not elsewhere classified				Unknown occupations			
		N	%	OR	95% CI	N	%	OR	95% CI
Lip	199	23	11.6	1.9	1.2–3.0 ^f	24	12.1	1.3	0.8–2.1
Oral cavity & oropharynx	1500	119	7.9	1.2	1.0–1.5 ^e	85	5.7	1.0	0.8–1.3
Salivary gland	96	7	7.3	1.1	0.5–2.4	8	8.3	1.4	0.6–3.0
Nasopharynx	75	9	12.0	1.6	0.8–3.3	2	2.7	0.4	0.1–1.8
Other pharynx	484	50	10.3	1.6	1.2–2.2 ^f	35	7.2	1.0	0.7–1.5
Esophagus	817	80	9.8	1.4	1.1–1.7 ^f	36	4.4	0.7	0.5–1.0 ^e
Stomach	2400	222	9.3	1.4	1.2–1.6 ^g	122	5.1	0.9	0.7–1.1
Cardia	616	46	7.5	1.2	0.9–1.7	26	4.2	0.8	0.5–1.2
Small intestine	276	24	8.7	1.3	0.8–1.9	23	8.3	1.4	0.9–2.2
Colon	3766	222	5.9	0.9	0.7–1.0 ^e	230	6.1	1.0	0.9–1.2
Rectum	2541	177	7.0	1.1	0.9–1.2	146	5.7	0.9	0.8–1.1
Liver	1172	92	7.8	1.0	0.8–1.3	56	4.8	1.0	0.7–1.3
Gallbladder & biliary tract	369	18	4.9	0.7	0.4–1.2	21	5.7	1.1	0.7–1.7
Gallbladder	132	6	4.5	0.6	0.3–1.5	11	8.3	1.4	0.8–2.8
Extrahepatic bile duct	237	12	5.1	0.8	0.4–1.4	10	4.2	0.8	0.4–1.6
Pancreas	1347	93	6.9	1.0	0.8–1.3	47	3.5	0.6	0.5–0.9
Peritoneum	100	5	5.0	0.8	0.3–1.9	7	7.0	1.2	0.5–2.8
Nose, sinuses, etc	125	10	8.0	1.2	0.6–2.2	4	3.2	0.5	0.2–1.3
Larynx	842	73	8.7	1.3	1.0–1.6	40	4.8	0.7	0.5–1.0
Lung	9106	754	8.3	1.3	1.2–1.4 ^g	419	4.6	0.8	0.7–0.9 ^g
Epidermoid	3974	340	8.6	1.3	1.1–1.5 ^g	186	4.7	0.9	0.8–1.0
Adenocarcinoma	2120	145	6.8	1.0	0.8–1.2	109	5.1	0.9	0.8–1.2
Small-cell carcinoma	1694	159	9.4	1.4	1.2–1.7 ^g	64	3.8	0.7	0.5–0.9
Giant-cell carcinoma	986	86	8.7	1.3	1.0–1.6 ^e	45	4.6	0.8	0.6–1.1
Pleura	310	15	4.8	0.7	0.4–1.2	9	2.9	0.5	0.2–0.9 ^e
Mesothelioma	215	11	5.1	0.7	0.4–1.4	4	1.9	0.3	0.1–0.7 ^e
Bone & cartilage	104	6	5.8	1.0	0.4–2.3	5	4.8	0.7	0.3–1.7
Soft tissue	354	18	5.1	0.8	0.5–1.3	23	6.5	1.1	0.7–1.7
Kaposi's sarcoma	288	8	2.8	0.4	0.2–0.9 ^e	21	7.3	0.9	0.5–1.4
Melanoma of the skin	1541	62	4.0	0.7	0.5–0.9 ^f	84	5.5	1.0	0.8–1.3
Head & neck	252	16	6.3	1.1	0.6–1.8	20	7.9	1.5	0.9–2.4
Trunk	695	25	3.6	0.6	0.4–0.9 ^e	33	4.7	0.9	0.6–1.3
Arm	338	10	3.0	0.5	0.3–1.0 ^e	19	5.6	1.0	0.6–1.6
Leg	246	11	4.5	0.9	0.5–1.7	11	4.5	0.8	0.4–1.5
Squamous-cell carcinoma	2471	158	6.4	0.9	0.8–1.1	294	11.9	1.3	1.2–1.5 ^g
Basal-cell carcinoma	6516	387	5.9	0.7	0.7–0.8 ^g	541	8.3	1.2	1.0–1.3 ^f
Breast	96	1	1.0	0.1	0.0–1.1	7	7.3	1.0	0.5–2.3
Prostate	9126	564	6.2	0.9	0.9–1.0	660	7.2	1.1	1.0–1.2
Testis	1112	39	3.5	0.8	0.5–1.1	107	9.6	1.0	0.8–1.3
Other male genital	200	13	6.5	1.1	0.6–1.9	10	5.0	0.6	0.3–1.2
Urinary bladder	3014	177	5.9	1.0	0.8–1.1	208	6.9	1.2	1.0–1.4 ^e
Kidney & urinary tract	1682	113	6.7	1.0	0.9–1.3	103	6.1	1.1	0.9–1.4
Kidney	1356	92	6.8	1.0	0.8–1.3	86	6.3	1.1	0.9–1.4
Renal pelvis	326	17	5.2	1.0	0.6–1.7	21	6.4	1.0	0.6–1.6
Eye & lacrimal gland	109	7	6.4	1.0	0.5–2.2	14	12.8	2.3	1.2–4.4 ^f
Brain & nervous system	879	58	6.6	0.9	0.7–1.2	24	2.7	0.5	0.3–0.7 ^g
Thyroid gland	320	18	5.6	0.8	0.5–1.3	17	5.3	0.8	0.5–1.3
Other endocrine glands	70	6	8.6	1.2	0.5–2.9	1	1.4	0.2	0.0–1.8
Non-Hodgkin's lymphoma	1125	62	5.5	0.8	0.6–1.1	82	7.3	1.1	0.8–1.4
Hodgkin's disease	345	21	6.1	1.0	0.6–1.6	16	4.6	0.7	0.4–1.2
Multiple myeloma	535	26	4.9	0.7	0.5–1.1	23	4.3	0.8	0.5–1.2
Leukemia	1322	71	5.4	0.8	0.6–1.0	80	6.1	1.0	0.8–1.2
Myeloid leukemia	543	29	5.3	0.8	0.6–1.2	34	6.3	1.1	0.8–1.6
Chronic lymphatic leukemia	514	29	5.6	0.8	0.6–1.2	33	6.4	1.0	0.7–1.4
Primary site uncertain	1262	100	7.9	1.0	0.8–1.2	69	5.5	0.9	0.7–1.2

^a The odds ratios have been adjusted for registry, age, civil status, period of diagnosis, nationality, and type of habitat.^b Occupations roughly specified, unclassifiable elsewhere and not frequent enough to be separately analyzed (ASCR code 21; see appendix 1).^c Unknown occupations, unemployed persons and retired persons (ASCR code 22; see appendix 1).^d According to the International Classification of Diseases for Oncology.^e P < 0.05.^f P < 0.01.^g P < 0.001.

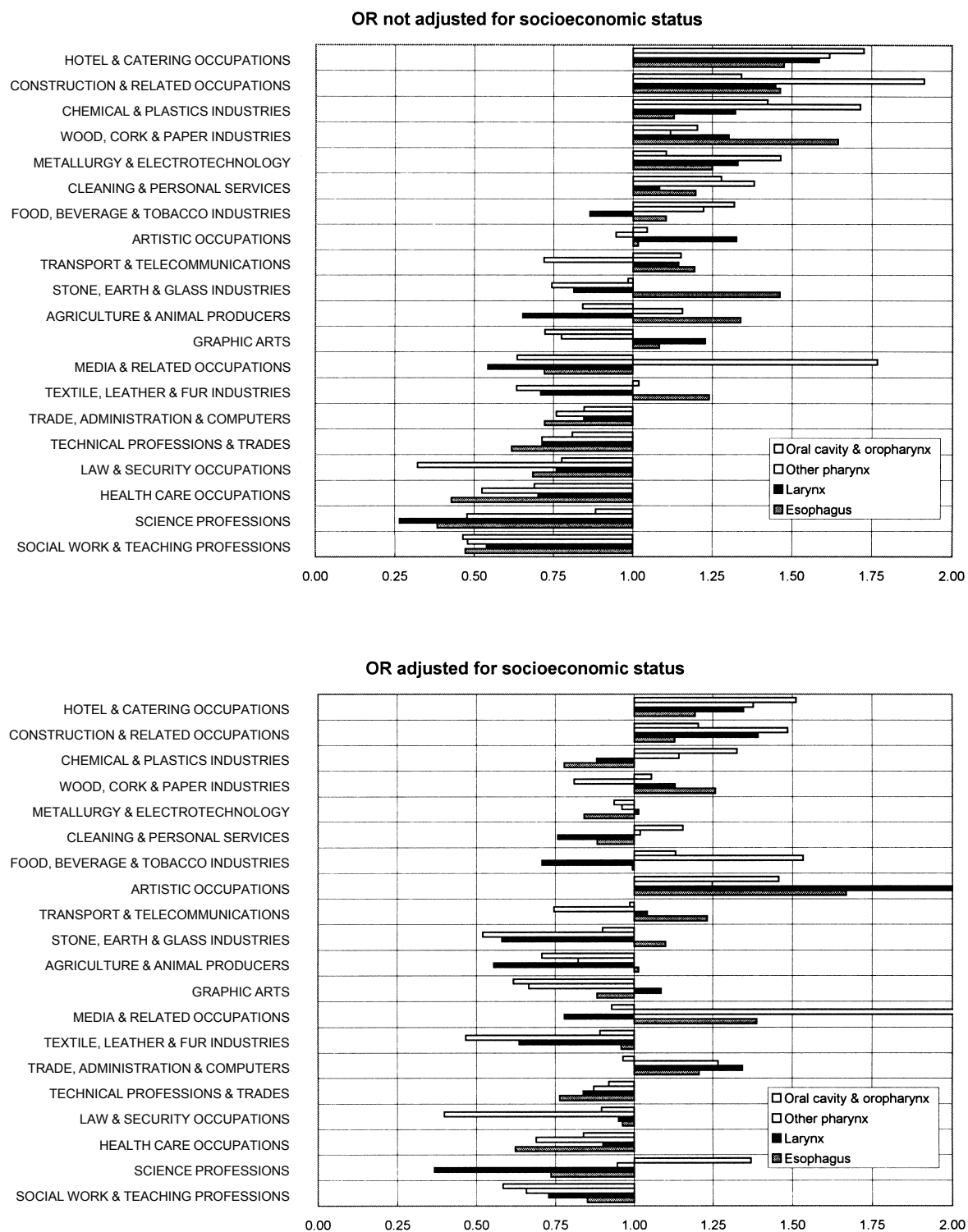


Figure 1. Effect of adjustment for socioeconomic status on the odds ratios (OR) with respect to tobacco- and alcohol-related cancers. The OR values have been adjusted for registry, age, civil status, period of diagnosis, nationality, type of habitat, and, when pertinent, histological confirmation of tumor, death certificate only cases. (Columns appear in the following order for each occupational category: oral cavity & oropharynx, other pharynx, larynx, esophagus)

Change of occupational exposure over time

The latency between occupational exposure and cancer occurrence can vary. However, schematically, the patterns of cancer risk observed in our study probably reflect occupational exposure during the 1950s and 1960s and not the effect of more recent changes in occupational practice. In Switzerland, as well as in other countries, occupational exposures have probably been declining over time (31) — mainly due to changes in processing, control facilities, exposure limits, or work practices. The results should therefore be assessed in view of these changing exposures.

Limitations of the case-referent approach

Only cancer cases were included in the study. As stated in the section on statistical methods, there was not enough concordance between incidence and census data to establish specific cancer rates by occupation. When population data cannot be used, the most appropriate analysis of incidence data consists of treating them as arising from a case-referent study in which cases comprise patients with cancer of a specific site and referents are all other cancer patients (14, 25, 26). In this context, logistic regression modeling offers flexibility and facilitates the consideration of the simultaneous effects of several variables. The critical assumption underlying this methodology is that referents are selected from cancers that have no relation to exposure, in other terms, that all sites of cancer, except the one of interest, are not related to one specific occupation. The odds ratios obtained this way are biased if there is an occupational variation also in the risk of total cancer. If the cancer incidence rate for the general population is the same as for the selected occupation, then odds ratios obtained by the case-referent approach will adequately estimate the true excess relative risk.

Additional analyses were performed excluding cancers sharing the same risk factors as the cancer of interest from the reference group. This approach obviously did not change the results. In particular, occupational patterns for tobacco-related cancers (such as oral cavity, pharynx, esophagus, larynx, and lung cancers) were not substantially modified after exclusion from the comparison group of all other cancers related to tobacco.

Power of the study

Even though it is based on more than 58 000 incident cases, the power of the study remains low for rare

occupations (and cancer sites). For example, the association between occupations in the pelt and leather industry (301 cases) and sinonasal cancer (126 cases) will reach significance only if there are at least three cases of sinonasal cancer in this occupation (ie, if the observed odds ratio exceeds 4.6).

Erroneous significance when rare cancers are studied

Without a priori hypotheses, interpreting results on rare cancers may be highly misleading. The overinterpretation of results based on small numbers is a well-known phenomenon. For any infrequent occupation for which only few cancer cases were observed, a significantly increased risk could be due to mere chance. Therefore, we did not interpret the occurrence of rare cancers without a priori hypotheses based on the relevant literature. (See the section on a priori hypotheses on this page).

Multiple comparisons

The problem of separate multiple comparisons arises in any large-scale routine descriptive epidemiologic study with systematic analysis of several causes of death, symptoms, or diagnoses. In our study, slightly over 6000 associations were investigated; thus some 300 significant results can be expected by chance only. Our main protection against the overinterpretation of such spurious significant results was provided by basing our discussion on the expected associations derived from the literature (formulation of a priori hypotheses). Information from other routine statistics can also be of help in the interpretation of the results. (See the section Comparison with the Swiss Mortality Statistics and Studies from Other Countries on page 20.) However, the results were not adjusted for the multiplicity of the tests performed, since the literature on this issue is controversial (32, 33). The essential argument of the opponents to multiplicity adjustments is that this method unfairly punishes large comprehensive studies. As P-values can be approximately inferred from the confidence interval (CI) given, anybody interested can make their own adjustments.

A priori hypotheses

In an attempt to avoid the misinterpretation of spuriously significant results, "a priori hypotheses" of what was expected to be observed were formulated according to results previously published in the literature. These a priori hypotheses constitute the framework for the

discussion on results by occupation. (See the section Cancer Profiles of Selected Occupations on pages 66–78.)

Comparison with the Swiss mortality statistics and studies from other countries

As has already been stated, for historical reasons, the cancer registries code occupations on the basis of the official classifications of occupations in use in Switzerland. These codes are mainly based on activity or economic sectors and are not compatible with the frequently used International Standard Classification of Occupations (ISCO) (19). In particular, for manual occupations, the major groups were defined according to activity sectors and type of manufactured products. For example, agricultural workers are considered “agricultural and animal producers” in the ASCR classification, but are listed as manual workers in the ISCO-88 classification. Occasionally, the ASCR classification also provides unusual combinations (ie, chimney sweeps, hairdressers and drycleaners are considered in the main group of occupations related to cleaning). Thus the results

concerning the 20 major occupational groups obtained in our study could not be compared with the results of other studies that used the ISCO-88 classification. Only results based on the 87 more-detailed occupational subgroups could allow, in certain situations, specific international comparisons.

Agreement between the study results based on incidence data and those previously reported on mortality data for the period 1979–1982 (2) has been systematically investigated. Because the classification used in previous mortality statistics (16) differed from the ASCR classification, additional analyses were performed (by Georges Schüller, “Recent Analyses of Swiss Mortality Data”; these analyses are indicated by “GS” in the rest of this document), and the classification was applied to the Swiss mortality data for the period 1979–1986. In the text, these new analyses are cited as “recent analyses on mortality data”.

With regard to the international literature, references are, by necessity, sparse, and not systematic. As extensively discussed elsewhere (34), the use of selected references, not representative of the available literature, may bias knowledge of the topic. To reduce this effect, we primarily used comparisons with recent reviews or meta-analyses.