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FIRE RISKS IN HOSPITALS

by

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October 1973

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SUMMARY

The fire statistics of hospitals, nursing homes etc are examined to establish the risks of these buildings. It is found that both the risk of fire and of personal injury are similar to those for dwellings. Fire deaths mainly occur following the ignition of bedding or clothing by matches and smoking materials. The fire record of the various departments of the hospital is examined.

Key Words: Fire statistics, hospitals, fire hazard, casualties

DEPARTMENT OF THE ENVIRONMENT AND FIRE OFFICES' COMMITTEE
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INTRODUCTION

The object of this note is to provide basic information about fires in hospitals to assist in assessing the safety of existing hospitals, the design of new hospitals, and in assessing the value of the various alternative remedial measures.

Previous studies[1] have presented data on the frequency of fire under different circumstances; in this note the emphasis is on estimating risks, expressed as a probability. More detailed statistics will be presented also to examine the fire risks in different departments.

Hospitals present special fire problems. They are large compared with most buildings to which the public is admitted, and they have special hazards associated with the equipment and materials used. There is a large population of patients, many of whom are disabled in one way or another, or unfamiliar with their surroundings, but there is also an efficient disciplined staff, accustomed to reacting rationally in an emergency, whose main concern is the welfare of the patient. Escape from fire will depend not only on fire characteristics but also on the disability of patients and capability of the staff. Outbreaks of fire arise not only from the normal day-to-day activities, but also from the disturbed mental condition of some types of patient. Clearly, fire risks need to be examined in the light of the size of building, number of occupants, action of brigades and staff, capability and awareness of patients.

An important factor in the design of hospitals is the relative risk of various departments, ranging from those with high life risk (from fire) such as wards to areas of high fire risk, such as kitchens. In certain circumstances the siting of the departments can be adjusted to minimise dangers from fire, so that areas of fire risk can be separated from areas of high life risk. In this paper, some data are presented which enable a crude estimate of the fire risk in different departments to be made.

Some type of patient are more at risk than others, particularly non-ambulant or mentally-handicapped patients. Unfortunately, there are insufficient data to examine this question in depth, and the discussion will be confined almost entirely to comparing non-mental and mentally ill or handicapped patients.

DATA

When this analysis was begun, the year 1967 was the most recent for which all fires reported to the United Kingdom fire brigades were available in a form suitable for computer analysis. For this reason, many of the figures in this report refer to 1967 only but, in some places, the numbers for 1968 to 1970 have been added to provide a broader data base. Except for fires involving fatal casualties, only a sample of one-quarter of the fire reports for 1968 is available in a coded form and one-half of the reports for 1969. The figure quoted for these years are estimated, therefore, from these samples.

The term 'Hospital' has been given a wider definition in this note than in previous work[1] and has been taken to include all members of class 8741 of the Standard Industrial Classification[2], except where confusion might be caused. This class is defined as those occupancies used by the:-

> 'National Health hospital service and privately operated hospitals (including dental hospitals, state institutions, war pensioner and Polish hospitals), sanatoria, nursing homes, mental homes, and similar institutions with their associated departments and clinics. Consultants both self-employed and employed in hospitals are included but general practitioners employed part-time in hospitals are excluded. The Public Health Laboratory Service, mass radiography and blood transfusion services, artificial limb and appliance centres, medical research institutions, Regional Hospital Boards, Boards of Governors, Hospital Management Committees and Boards of Management are included. Institutions operated by the Service Departments are excluded.'

Except in Table 1, fires in hospital buildings under construction or demolition have been omitted from this note.

Where statistical significance levels are stated, the terms used are:-

Highly significant	:	significant at the 1% level or better,
Significant	:	significant at the 5% level or better, and
Not significant	:	not significant at the 5% level.

A. FIRE FREQUENCY

The Hospitals Year Book[3] for 1969 contains a list of hospitals, etc., correct at 31 December 1967. At this time there were some 3150 hospitals, clinics, etc. This figure only included those establishments providing beds for patients and not all the occupancies comprising Standard Industrial Class 8741. It was found that some 8 per cent of hospital fires occurred in places not listed in the Year Book and, by removing the fires in unlisted addresses from the 712 fires in hospitals during 1967, we obtain a comparative figure of 652 fires to which the brigade was called. Thus, the annual probability of such a fire occurring in a hospital was:

$$p_f = \frac{652}{3150} = 0.207$$

In Table 1 this is compared with the values of p_f for various occupancies[4] and it may be seen that the value for hospitals is much higher than any other. Some possible explanations of this are that either hospitals are almost twice as fire-prone as any other listed occupancy, that hospitals are much larger than the other buildings considered, or that the brigades are called to smaller fires in hospitals. These ideas are more fully explored in section B of this note.

The upper curve of Fig.1 shows the hospital fire frequency for the years 1967 to 1970. Since the years 1968 and 1969 are based on a sample of fire reports, only an estimated frequency can be obtained for those years but statistical theory enables limits to be drawn for the most likely values. The lower curve of Fig.1 shows the hospital fire frequency as a proportion of the fire frequency in all buildings. Thus, the Figure shows that not only is the reported number of fires in hospital premises increasing but that it is increasing at a faster rate than all building fires. However, there is evidence that a good part of the increase is due to the brigade being called to smaller fires in more recent years (see Section B).

The average daily number of occupied beds in hospitals in Great Britain is available[3] and, after allowing for those occupancies in Class 8741 which are not hospitals, the fire hazard rate can be calculated in terms of fires per patient per 10^8 exposed hours, assuming that the patients are exposed to risk for 24 hours each day. This is shown in Fig.2 and is also found to be increasing. For dwellings, the rate is 10 fires per person per 10^8 exposed hours and, for hotels[6], it is 145 fires per guest per 10^8 exposed hours (based on 16 and 12 exposed hours per person per day respectively). For comparison, the rate for hospitals lies between approximately 16 and 30 fires per patient per 10^8 exposed hours.

A sample of some 1100 hospitals, specified by the Hospitals Year Book[3] (1969) as treating in-patients, was examined and the hospitals found to hold 190 beds on average. Those hospitals providing care for the mentally ill or subnormal were found to comprise only 16% of the sample but had an average size of about 490 beds. These figures compare satisfactorily with those for the allocation of beds in English and Welsh hospitals during 1967[3], when some 43% of beds were allocated to mental patients. The distribution of hospital sizes is shown in Fig.3, both for all hospitals and for mental hospitals only. The scale on the vertical axis indicates the probability that, for a hospital chosen at random, the number of beds will be less than, or equal to, the number of beds shown on the horizontal axis. For instance, the probability that any one hospital will contain 500 beds or less will be 0.92 for all hospitals but only 0.67 for mental hospitals.

The fire reports were studied to ascertain the type of premises in which fires occurred. Thirty-two per cent of the fires were in mental hospitals, 6 per cent in nursing homes and the remainder mainly in non-mental hospitals (which may, however, include mental wards). Using this sub-division of hospitals and obtaining the numbers at risk from the Hospitals Year Book[3], we can calculate the probability of a hospital having a fire. For 1967, we obtain the values:

Mental hospitals : 0.40 fires/hospital/annum

Other hospitals : 0.19 fires/hospital/annum

Assuming that both types of hospital have the same proportion of beds occupied, these figures can be expressed as the risk per patient per exposed hour and, for 1967, we have:

Mental hospitals : 13 fires/patient/10^8 exposed hours

Other hospitals : 19 fires/patient/10^8 exposed hours;

the previously greater risk of mental hospitals being due to their greater mean size. Not all mental patients are confined to the hospital for the whole day and this could mean that the figure for mental hospitals should be increased somewhat. It seems probable that there is no significant difference in the fire risk to the individual patient in either type of hospital.

The average length of time before a fire in a hospital (called the 'return period' for that hospital) can be calculated from the probabilities and is found to be 2.0 years for a mental hospital and 4.7 years for other hospitals; ie on average, fires are expected once every 2 years in mental hospitals and once every 4.7 years in others.

B. SIZE OF FIRES

The means used to fight hospital fires are shown in Tables 2 and 3 and compared with fires in other types of building. Table 2 shows that a much higher proportion (77 per cent) of hospital fires are fought before the arrival of the brigade than is generally the case. Furthermore, a far larger proportion are out when the brigade arrive (Table 3) and smaller means tend to be used to fight the remainder. The brigades might be expected to use similar equipment on fires whatever the occupancy and, if so, it would then appear that fires in hospitals are smaller on average than is general.

This view is supported by data[4] on fire spread presented in Table 4. The value of p_s, the probability of spread beyond the room of origin (calculated for fires which have spread beyond the item ignited first) is only half that for the next lowest occupancy. It should be noted, however, that the term 'room' is ambiguous and in hospitals a room could be very large.

Clearly, the hospital staff play an important role in limiting the effects of fire. Seventy-seven per cent of fires were fought before the arrival of the brigade and, of these, 70 per cent were out when brigade arrived. It is also possible that the brigade are called to smaller fires; those that they do fight tend to be smaller than in other buildings.

Let us now examine the apparent increase in frequency of fires during the period studied (Fig. 1). There have been a number of fire disasters in hospitals in recent years, and it is quite possible that staff were more fire-conscious and more likely to call the brigade. To examine this hypothesis, the fires have been divided into two categories designated large and small. This is an arbitrary distinction, which has been made using three different criteria:

1) Fought by brigade/out on brigade arrival

2) Control time greater than 15 min/less than 15 min

3) Spread beyond room of origin/did not spread beyond room of origin.

It was found that the number of large fires increased by about 20 per cent over the period studied, a similar increase to that for fires in all types of building in the same period. Hence, the additional increase in the frequency of hospital fires is due largely to an increase in the number of small fires.

It may be noted that in this period there was a greater emphasis on fire safety following the Shelton tragedy[7]. It seems likely that the increase in the number of small fires is due to an increased willingness to call the brigade.

C. EVACUATION OF PERSONS

The number of persons escaping or rescued from burning buildings is not, in general, reported very accurately, especially as those people escaping by their own unaided efforts are sometimes not mentioned at all. It is reasonable, however, to consider that the figures for hospitals are more accurate, at least for the higher numbers of persons. This follows from the greater difficulty of, and concern with, the evacuation of patients. Table 5 shows the estimated number of persons evacuated from hospitals from 1967 to 1970, the years 1968 and 1969 being estimated from samples. The table shows that evacuation or rescue was necessary in only 0.6 per cent of fires and the evacuation of more than 4 persons in 0.3 per cent. Thus, the necessity of evacuation arises only rarely. When it does occur, the number of people involved may be considerable; in the Carlton Hayes fire[8], 34 people were rescued and a further 120 patients evacuated.

D. CASUALTIES

In the years 1967 to 1970, an estimated 114 hospital fires caused casualties, giving the probability of a fire causing a casualty as 0.030. The number of fires causing fatalities during this period was 28 and so the probability of a fire in a hospital leading to fatal injuries was 0.007. These probabilities are lower than those found in houses[9] (0.063 and 0.011 respectively) but, if the brigade was called to smaller fires in hospitals (see section B), they are not strictly comparable. The number of persons injured in each fire is shown in Table 6. The figures for non-fatal injuries had to be estimated from a sample of reports for 1968 and 1969, but all reported deaths are included in the fatal injuries.

The distribution of casualty fires in time is shown in Fig.4. With such small frequencies, the results are very scattered but the moving averages do indicate some trend. The peak time for fires involving either fatal or non-fatal casualties appears to be the afternoon, with a secondary peak at about mid-night. This is also broadly the pattern of all hospital fires (Fig.5) but the afternoon peak then extends into the evening.

The 'status' of the injured person is studied for 1967 in Table 7 and it can be seen that, although more staff were injured than patients, their injuries were the more minor. It seems probable that many of the staff injuries were received while fighting the fires and this would explain the greater number injured, despite the fact that there would be fewer staff than patients in a hospital. Twelve (92 per cent) of the patients' injuries resulted from the ignition of

bedding or clothing, while 7 (47 per cent) of the staff injuries followed the ignition of solvents. Two nurses were injured by gas explosions in domestic-type cookers and a further two staff by the overheating of deep-fat fryers.

Table 8 shows the source of ignition and the material it ignited for fatal fires in hospitals from 1967 to 1970. It is clear that clothing/bedding are the materials most commonly ignited and smokers' materials the most common source of ignition. In combination, these are the most common cause of fatal fires in hospitals, but these fires killed only the person originally involved. In most other cases this is also true and in these fires the structure of the building played no part. Thus, regulations controlling the building construction would not have lowered the number of fatal fires significantly. If patients' bedding and clothing could be made flame-resistant, the number of fatal fires might have been reduced by 70 per cent and the number of deaths by 40 per cent, presuming that the new materials did not increase the smoke or toxic gas hazard. Research into the problems of using flame-resistant clothing and bedding for hospital patients is being conducted[10,14] and encouraging progress is reported from the United States[11,15]. In at least one case[12], a patient has been saved from possibly fatal burns by wearing flame-resistant pyjamas. If it were possible to eliminate fires which ignited bedding, clothing or upholstery, the number of fatal fires would be reduced by 80 per cent and the number of deaths by 90 per cent (that is, an average of over 13 deaths per year would be prevented). This may indicate a rewarding line of investigation.

An area in which building regulations might prove effective is the reduction of multiple death fires. There were no multi-fatal fires in hospitals from 1964 to 1967 but there was one in each of the next three years. These were:-

Year	Hospital	No. of deaths
1968	Shelton[7]	24
1969	Carlton Hayes[8]	4
1970	Exeter[13]	5

All involved mental patients and the victims at Exeter were elderly. The first two were attributed to the ignition of upholstered chairs in lounges by smoking materials and the third to the 'malicious' ignition by a mentally-disturbed patient of his bedding. All three fires were discovered between midnight and 0300 hours, and heavy smoke was also a common factor. In these cases, increased provision of smoke-stop doors and/or automatic detection might have reduced the number of deaths. A more detailed examination of the 1967 casualties showed that two of the five fatally injured patients were in mental hospitals, while a third was in a geriatric ward. Of the 9 cases of non-fatal injuries to patients, 4 were

in mental hospitals and 3 in geriatric hospitals. Thus, 10 of the 14 cases of injury to patients occurred in these hospitals and the life-hazard to patients elsewhere was very small.

The casualty rates for 1967 are shown in Table 9. The overall rate was about 1 casualty per 100 hospitals per year, with the rate for mental hospitals being twice this. For patients, the casualty rate in mental hospitals was two or three times that in all hospitals but there were more patients at risk. To allow for this, Table 10 shows the casualty rates in terms of the number of occupied beds, indicating no significant difference between the patient casualty rates. The large difference between the rates for staff may indicate a lower staff/bed ratio in mental hospitals, as there seems no other obvious explanation of the difference. Overall, the difference in risk between mental hospitals and all hospitals was not large and is explainable by the difference in fire incidence between the two types (see Section A). If the risk of death in a hospital fire during 1967 is compared with that in dwellings and hotels[6], we obtain:

Hospitals : 0.12 deaths/person/10^8 exposed hours

Dwellings : 0.17 deaths/person/10^8 exposed hours

Hotels : 1.87 deaths/person/10^8 exposed hours

The number of deaths in hospitals[1] did not vary greatly over the years 1963 to 1967, 1967 being only slightly below the mean value, but the multi-fatal fires have since increased it considerably. For the years 1967 to 1970, the fatality rate (F) was found to be:

1967 : F = 0.12 deaths/patient/10^8 exposed hours

1968 : F = 0.65 deaths/patient/10^8 exposed hours

1969 : F = 0.24 deaths/patient/10^8 exposed hours

1970 : F = 0.36 deaths/patient/10^8 exposed hours

Mean : F = 0.34 deaths/patient/10^8 exposed hours

With the small number of deaths in hospitals, chance fluctuations are bound to exert a large influence on the statistics and reduce their individual usefulness; also the figures are influenced by the occasional multiple fatal fire. The mean fatality rate should, however, provide a reasonable working estimate of the life-risk in a hospital.

E. EFFECT OF BUILDING AGE

It is to be expected that newer buildings are better protected against fire than older ones. In the case of hospitals, this hypothesis cannot be tested directly since the number of hospitals of different ages is not known and so the size of fires in hospitals of different age was studied using the methods of Section B. To increase the accuracy of the data, fires from 1967 to 1970 have been considered, although for the years 1968 and 1969 only a sample of reports was available.

The proportions of fires fought before the arrival of the brigade and by the brigade are shown in Table 11 for hospitals of different ages. The differences are small and not statistically significant. In Section B, it has been assumed that a high proportion of small fires is indicated by a high probability of a fire being fought before the arrival of the brigade, and a low probability of a fire being fought by the brigade. The absence of significant variations in Table 11 would then indicate that the age of the building has no effect on fire size.

The spread of fire in hospitals of different age is shown in Table 12. Two measures are used to study this: p_A, the probability of a fire being confined to the appliance or item first ignited and p_R, the probability of a fire being confined to the room of origin (which includes those confined to the original item); fires in single-compartment buildings being excluded in both cases. The differences in the number of fires reported in each spread category for the various ages of hospital were statistically highly significant. This indicates that, although the variation in the confinement probabilities is small, their differences with age of building are larger than would be expected from random fluctuations. The probability of a fire being confined to the item first ignited is highest for the newer building but the probability of a fire being confined to the room of origin once it has spread beyond the first item is lower for these buildings. It appears that appliances in the newer hospital are safer from a fire-spread point of view but that, once a fire has spread beyond the original item involved, it tends to spread further in the newer hospital. However, the differences could be due to changes in the reporting or coding procedures, and this requires further investigation.

The effect of building age on the number and severity of casualty fires was also examined but no trends were found. The number of casualty fires available for study was small and only the most marked of trends would have been observable.

To summarise, where variation exists between the reported fire behaviour of different ages of hospital, such variation is slight.

P. FIRE RECORD OF DIFFERENT DEPARTMENTS

Many of the statistics given in previous sections for the whole hospital can be subdivided to give information on the behaviour of fires in the more important areas of the hospital. The numbers of fires in the selected areas are shown in Table 13, together with the proportion of hospital fires in each area. The relative frequencies of fires in the various areas are similar from year to year, with a few exceptions. Most fires occur in wards, kitchens and stores, but in view of the very different relative size of these departments, the frequency does not give a true picture of the risk of a fire in a given kitchen, store or ward. We must find the risk of fire in a given department in relation to its size.

In a homogeneous population, the chance of fire in a given room is in proportion to its area, so that in a room of area A, the probability of fire, p, is

$$p = Ap_a$$

where p_a is the probability of fire per unit area for that department.

Now consider the entire population of hospital buildings. If an area A_d is devoted to department d, and if n_d is the frequency of fire in the department, then

$$p_a = \frac{n_d}{A_d}$$

The number of fires n_d is given in Table 13, but there are no published data on the areas devoted to each department.

The plans of some proposed hospital projects have therefore been analysed, and scaled in proportion to the size of the hospital, that is, in proportion to the number of beds in the hospital. Assuming that this sample is representative of the entire hospital population, and knowing the total number of beds in hospitals, this gives a crude estimate of A_d. Combining these data with fire data gives an estimate of p_a, shown in Table 14. There may be different areas allocated in the older hospital but it is unlikely that such differences would be sufficient to affect the results greatly, since there is an order of magnitude involved in these.

These are only crude estimates, and only the principal departments have been analysed. However, it is apparent that the risk of fire per unit area is much greater in catering and stores than the risk in wards, offices or laboratories.

Hence, catering and stores present a far greater hazard in relation to their size than do the other departments analysed.

The probability of non-fatal casualties (p_C) or fatal casualties (P_F) occurring in different areas of the hospital, given that a fire has occurred, is shown in Table 15. The number of fatal fires is rather small for reaching firm conclusions but it appears that the probability of a fire causing fatal casualties is highest in wards and bedrooms. The occupancy 'bedroom' is intended to mean only staff bedrooms but it is found that private wards are often included. When these are allowed for, the casualty rates (both fatal and non-fatal) for wards are not greatly increased but those for bedrooms approach the mean value. However the very high risk quoted for bedrooms indicates particular hazard for the occupants of private wards, where the patient is out of sight of both staff and fellow patients. The number of non-fatal casualty fires is small enough to allow a considerable amount of random variation but there does appear to be genuine variation between the values of p_C for different departments. Lavatories, wards and laboratories have the highest probability of a fire causing a casualty, when the confusion over the definition of a bedroom has been removed.

Table 16 gives details of fire spread and, hence, of fire size; while in Table 17 this is summarised in the form of the two statistics previously described, p_A and p_R. About one-quarter of all hospitals fires were confined to the item first ignited and only 6 per cent spread beyond the room of origin. Only 0.5 per cent of hospital fires spread beyond the building of origin, whereas the figure for all buildings was 3.3 per cent.

The proportion of fires needing to be fought by the brigades is given in Table 18. Only half the fires in hospitals need professional fighting, substantially lower than the average value (75 per cent) for all types of buildings. Only 25 per cent of fires in wards needed professional fire-fighting, but in boiler-rooms and refuse disposal areas, the brigade were required between 80 per cent - 90 per cent of the time. It is clear that patients and staff make a considerable contribution to the safety of hospitals and, in areas where there is a high concentration of people, fires are usually small. In the more remote areas (such as storerooms, boiler-rooms, refuse disposal areas) fires tend to require brigade fire-fighting, presumably because of later discovery, and possibly because of the volume of material at risk.

An important feature of a fire is the amount of smoke it produces and this is especially true in hospitals, where smoke may make it essential to evacuate wards not otherwise threatened by fire. The travel of smoke and gases has also

been responsible for large life-loss fires[7] in hospitals. No direct measure of smoke production is available from the brigade reports but it is stated when breathing apparatus (BA) sets were used. From this can be calculated the proportion of fires in which BA sets were required, which is an estimate of the probability (p_{BA}) that any fire will require the use of a BA set. This measure indicates how often the amount of smoke and gases from a fire were considered by the fire brigade to exceed some threshold value. When BA sets were used, it must be considered that the fire area would be impassable for unprotected persons, and in the absence of suitable smoke-stop doors, appreciable amounts of smoke would penetrate to other parts of the building. There were insufficient data to study the values of P_{BA} for the various hospital departments but the overall figures for hospitals and all buildings (0.09 and 0.11 respectively) are not significantly different.

The ignition source and material first ignited in fires in the selected areas of the hospital during 1967 are given in Tables 19-30. For each area, the sources and materials are arranged with the most numerically important at the head of the table. Figures for the whole hospital are available (in a rather different classification) elsewhere[1]. It may be noted that the term 'textiles', as used in the material tables, includes rags, fluff and clothing. The sources and materials vary from one department to another, particularly between those occupied by patients and those not. The predominance of fires started by smoking materials and malicious ignition is apparent, particularly between those occupied by patients and those not. The predominance of fires started by smoking materials and malicious ignition is apparent, particularly in living and sleeping quarters. Chandler's data[1] show that, between them, smoking materials and malicious ignition account for 42 per cent of all fires in hospitals.

CONCLUSIONS

1. The chance of an individual hospital patient dying by fire is similar to the chance of the individual dying by fire in a private house. In recent years, hospital fire deaths have been confined to patients in psychiatric or geriatric care[16], implying that the fire risk to patients in acute wards is lower than in the home.

2. Most injuries to patients arose from the ignition of clothes or bedding. If it were possible to eliminate those fires in which bedding, clothing or upholstery were ignited, the number of deaths would have been reduced by 90 per cent.

3. More hospital staff than patients were injured by fire but only patients died from fire in the year examined (1967). Most fire injuries to staff followed the ignition of solvents.

4. Only 0.6 per cent of hospital fires required rescue or evacuation of persons but the number of people involved may be large (34 rescued and 120 evacuated in one incident).

5. The frequency of reported fires has increased rapidly in recent years but it is found that the increase is mainly in the number of small fires, indicating, probably, an increased willingness to call the brigade.

6. The number of fires per person in hospitals is similar to that in private houses. The relatively high number of fires reported from hospitals is largely due to the number of patients accomodated.

7. The number of fires per patient is about the same for mental and other hospitals. Due to the greater average size of mental hospitals, the average number of fires in these hospitals is greater than for other hospitals.

8. Seventy-seven per cent of fires are fought before the arrival of the brigade and, of these, 70 per cent are out on arrival of the brigade. Those that the brigade do fight, tend to be smaller than is general in other types of buildings.

9. Most hospital fires occurred in wards, kitchens and storerooms. The chance of fire per unit floor area was found to be much greater in catering and storage areas than in wards, offices or laboratories.

10. Little evidence was found of any difference in the fire record of hospitals in older or newer buildings.

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Table 1

The annual probability of a fire in various occupancies

Occupancy	Annual No. of fires	No. of buildings	p_f
Hospitals	712 (652)	(3 150)	(2.1×10^{-1})
Assembly - entertainment	1 446	12 540	1.2×10^{-1}
Industry	8 075	183 377	4.4×10^{-2}
Residential - clubs, hotels etc	1 352	36 609	3.7×10^{-2}
Assembly - non-residential	2 810	143 019	2.0×10^{-2}
Storage	2 420	199 612	1.2×10^{-2}
Commercial - shops	5 574	664 817	8.4×10^{-3}
Commercial - offices	866	152 430	5.7×10^{-3}
Houses	38 142	14 202 359	2.7×10^{-3}

Table 2

Probability of using various methods of fire-fighting before the arrival of the brigade, 1967

Method of fire-fighting	No. of hospital fires	Probability for:		Significance of differences(1)
		Hospitals	All buildings	
None	153	0.23	0.55	*
Small means	437	0.83	0.89	-
Hose-reel jets,etc	86	0.16	0.09	*
Jets from pumps and hydrants	4	0.01	0.01	-

Table 3

Probability of the fire brigade using various methods of fire-fighting, 1967

Method of fire-fighting	No. of hospital fires	Probability for:		Significance of differences(1)
		Hospitals	All buildings	
None	335	0.49	0.25	*
Small means	113	0.33	0.20	*
Hose-reel jets, etc	189	0.55	0.60	-
Jets from pumps and hydrants	43	0.12	0.20	*

(1) The statistical significance of the probability differences :

* Very highly significant

\- Not significant

Table 4

The probability of fire spread beyond the room of origin in various occupancies

Occupancies	Number of fires	Probability of spread (p_s)
Hospitals	.422	0.07
Residential	37 118	0.14
Financial, professional, etc	3 008	0.21
Hotels, restaurants, etc	2 318	0.22
Public administration and defence	632	0.23
Distributive - retail	2 072	0.25
Public entertainment	478	0.30
Transport and communications	464	0.31
Manufacturing industries	6 948	0.32
Distributive - other	808	0.41

Table 5

Escapes and Rescues

Escapes and Rescues, 1967-1970 (estimated)							
Number of persons	0	1	2	3	4	over 8	All numbers
Number of fires	3780	9	1	2	1	11	3804

Table 6

The number of fires leading to casualties, 1967-1970

Type of injury	Total	Number of persons injured						
		0	1	2	3	4	5	24
Non-fatal* (percentage)	3804 (100.0)	3718 (97.7)	76 (2.0)	9 (0.2)	1	0	0	0
Fatal (percentage)	3804 (100.0)	3776 (99.3)	25 (0.7)	0	0	1	1	1

*Estimated

Table 7

The "status" of injured persons, 1967

Type of casualty	"Status" of person				
	Patient	Staff	Fire brigade	Not stated	Total casualties
Non-fatal (percentage)	9 (30)	15 (50)	3 (10)	3 (10)	30 (100)
Fatal (percentage)	4 (80)	- (-)	- (-)	1 (20)	5 (100)
Total (percentage)	13 (37)	15 (43)	3 (9)	4 (11)	35 (100)

Table 8

Ignition source and material ignited,
fatal fires, 1967-1970

Source of ignition	Material first ignited				
	Clothing on person/bedding	Upholstery/ cushions	Unspecified waste	Unknown	Total
Smoker's materials	10 (10)	3 (29)	0	1 (1)	14 (40)
Matches/ naked lights	3 (3)	0	1 (1)	0	4 (4)
Malicious ignition	4 (8)	0	0	0	4 (8)
Slow combustion stove	1 (1)	0	0	0	1 (1)
Unknown	2 (2)	0	0	3 (3)	5 (5)
Total	20 (24)	3 (29)	1 (1)	4 (4)	28 (58)

Number of deaths in brackets

Table 9

The number of casualties per thousand hospitals per annum, 1967

'Status' of casualty	Type of casualty	Mental hospitals	All hospitals
Patient	Non-fatal	7.0	2.6
	Fatal	1.8	1.1
	Total	8.8	3.7
Staff	Non-fatal	3.5	4.3
	Fatal	0	0
	Total	3.5	4.3
All persons (except fire brigade)	Non-fatal	14.0	7.7
	Fatal	3.5	1.4
	Total	17.5	9.1

Table 10

The number of casualties per person per 10^8 exposed hours, 1967

'Status' of casualty	Type of casualty	Mental hospitals	All hospitals
Patient	Non-fatal	0.22	0.21
	Fatal	0.05	0.09
	Total	0.27	0.30
Staff	Non-fatal	0.11	0.35
	Fatal	0	0
	Total	0.11	0.35
All persons (except fire brigade)	Non-fatal	0.43	0.63
	Fatal	0.11	0.12
	Total	0.54	0.74

Table 11

Fire-fighting in hospitals of different age, 1967-1970

	Age of building				
	pre-1920	1920-1949	post 1949	Unknown	All
Probability of fire being fought before brigade arrival	0.80	0.77	0.73	0.78	0.78
Probability of fire being fought by brigade	0.40	0.44	0.45	0.43	0.42

Table 12

Fire spread in hospitals of different age, 1967-1970

	Age of building				
	pre-1920	1920-1949	post 1949	Unknown	All
Probability of fire being confined to item of origin p_A	0.46	0.47	0.53	0.49	0.48
Probability of fire being confined to room of origin p_R	0.96	0.94	0.92	0.96	0.95

Table 13

The number of fires in different areas of the hospital, 1967-1970

Part of building	Estimated No. of fires	Percentage of total
Ward	610	16.1
Kitchen	491	13.0
Store-room	371	9.8
Access ways	263	6.9
Lavatory, bathroom	260	6.9
Lounge, common room	198	5.2
Laundry	158	4.2
Bedroom	128	3.4
Boiler-room	120	3.2
Refuse disposal area	114	3.0
Office	101	2.7
Laboratory	76	2.0
Other (known)	471	12.4
Unknown	427	11.3
All	3 788	100.0

Table 14

The probability of fire per unit area
for different areas, 1967-1970

Part of building	Mean area/1000 beds (m^2)	No. of fires, 1967-1970	Fires/m^2/year[/] (p_a)
Wards, etc*	22 940	936	1.9×10^{-5}
Catering	1 710	491	1.4×10^{-4}
Stores	1 220	371	1.4×10^{-4}
Offices	2 410	101	2.0×10^{-5}
Laboratories	2 880	76	1.3×10^{-5}

* Includes bedrooms, lounges, and common rooms

/ Assuming 525 000 beds in all hospitals

Table 15

The proportion of fires causing fatal (p_F) or non-fatal (p_C) casualties, 1967-1970

Part of building	Non-fatal casualties (estimated)		Fatal casualties	
	Number of fires	p_C	Number of fires	p_F
Ward	24	0.039	17	0.028
Kitchen	14	0.029	-	-
Store-room	4	0.011	-	-
Access ways	1	0.004	-	-
Lavatory, bathroom	11	0.042	3	0.012
Lounge, common room	1	0.005	2	0.010
Laundry	5	0.032	-	-
Bedroom	10	0.078	2	0.016
Boiler room	3	0.025	-	-
Refuse disposal area	1	0.009	-	-
Office	-	-	-	-
Laboratory	3	0.039	-	-
Other (known)	3	0.006	3	0.006
Unknown	6	0.014	1	0.002
ALL	86	0.023	28	0.007

Table 16

The extent of fire in different parts of the hospital, 1967

(Percentages)

Part of building	Fire confined to:									Fire extended to:		All extents
	Exterior components	Access ways	Appliance of origin	Room of origin		Floor of origin	Building of origin:			Separate buildings	Other hazards	
				Contents only	Structure		One compartment	Single storey	Multi storey			
Ward	-	-	7	62	30	1	-	-	-	-	-	100
Kitchen	-	-	50	13	35	-	1	-	1	-	-	100
Store-room	-	-	6	31	37	3	17	-	5	2	-	100
Access ways	-	63	26	4	4	2	-	-	-	-	-	100
Lavatory, bathroom	-	-	8	44	42	-	-	-	6	-	-	100
Lounge, common room	-	-	13	35	39	9	-	4	-	-	-	100
Laundry	-	-	41	41	19	-	-	-	-	-	-	100
Bedroom	-	-	10	59	21	10	-	-	-	-	-	100
Boiler-room	-	-	63	19	13	-	6	-	-	-	-	100
Refuse disposal area	4	7	4	21	7	-	50	4	4	-	-	100
Office	-	-	14	38	43	-	-	-	-	5	-	100
Laboratory	-	-	33	28	28	-	6	6	-	-	-	100
Other (known)	24	-	14	18	18	-	16	6	2	1	1	100
Unknown	-	-	31	40	22	1	3	-	3	-	-	100
ALL	3.7	4.6	22.4	31.3	26.2	1.5	6.8	1.3	1.8	0.4	0.1	100.0

Table 17

Fire spread in different parts of the hospital, 1967

Part of hospital	p_A	p_R
Ward	0.07	0.99
Kitchen	0.51	0.99
Store-room	0.07	0.89
Access ways	0.71	0.94
Lavatory, bathroom	0.08	0.94
Lounge, common room	0.13	0.87
Laundry	0.41	1.00
Bedroom	0.10	0.90
Boiler room	0.64	1.00
Refuse disposal area	0.09	0.82
Office	0.14	0.95
Laboratory	0.31	0.94
Other (known)	0.23	0.86
Unknown	0.31	0.96
ALL	0.26	0.94

Table 18

The probability of a fire being fought by the fire brigade, 1967

Part of building	p
Ward	0.25
Kitchen	0.52
Store-room	0.74
Access ways	0.30
Lavatory, bathroom	0.35
Lounge, common room	0.48
Laundry	0.50
Bedroom	0.34
Boiler-room	0.88
Refuse-disposal area	0.86
Office	0.43
Laboratory	0.56
Other (known)	0.51
Unknown	0.44
All	0.51

Table 19A

Sources of ignition in ward fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	34	42	(47)
Malicious	14	17	(19)
Matches	7	9	(10)
Other (known)	17	21	(24)
Unknown	9	11	
TOTAL	81	100	(100)
*Percentage of known in brackets			

Table 19B

Material first ignited in ward fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Furniture, furnishings	41	51	(58)
Unspecified waste	9	11	(13)
Textiles	4	5	(6)
Structure	4	5	(6)
Electrical insulation	4	5	(6)
Other (known)	9	11	(13)
Unknown	10	12	
TOTAL	81	100	(100)
*Percentage of known in brackets			

Table 20A

Sources of ignition in kitchen fires, 1967

Source of ignition	No. of fires	Percentage of fires
Deep frying range	54	53
Ring, hot plate	17	17
Oven	8	8
Cooker (unspecified)	5	5
Refrigerator	4	4
Smoking materials	4	4
Other (known)	9	9
TOTAL	101	100

Table 20B

Material first ignited in kitchen fires, 1967

Material first ignited	No. of fires	Percentage of fires
Food - fat	69	68
Textiles	6	6
Furniture, furnishings	5	5
Gases	4	4
Unspecified waste	4	4
Other (known)	13	13
TOTAL	101	100

Table 21A

Sources of ignition in store-room fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	22	34	(47)
Naked lights	4	6	(9)
Malicious	3	5	(6)
Blowlamp	2	3	(4)
Children with fire	2	3	(4)
Other (known)	14	22	(30)
Unknown	18	28	
TOTAL	65	100	(100)

Table 21B

Material first ignited in store-room fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Textiles	10	15	(23)
Unspecified waste	9	14	(20)
Cleaning materials	6	9	(14)
Electrical insulation	6	9	(14)
Furniture, furnishings	4	6	(9)
Packing materials	4	6	(9)
Other (known)	5	8	(11)
Unknown	21	32	
TOTAL	65	100	(100)

*Percentage of known in brackets

Table 22A

Sources of ignition in access way fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Lift	14	30	(34)
Smoking materials	11	24	(27)
Malicious	5	11	(12)
Refrigerator	2	4	(5)
Other (known)	9	20	(22)
Unknown	5	11	
TOTAL	46	100	(100)

Table 22B

Material first ignited in access way fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Electrical insulation	16	35	(38)
Furniture, furnishings	7	15	(17)
Unspecified waste	6	13	(14)
Other (known)	13	28	(31)
Unknown	4	9	
TOTAL	46	100	(100)

*Percentage of known in brackets

Table 23A

Sources of ignition in lavatory and bathroom fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	24	50	(57)
Incinerator	6	13	(14)
Malicious	4	8	(10)
Blow lamp	2	4	(5)
Matches	2	4	(5)
Other (known)	4	8	(10)
Unknown	6	13	
TOTAL	48	100	(100)

Table 23B

Material first ignited in lavatory and bathroom fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Unspecified waste	12	25	(29)
Textiles	9	19	(22)
Packing materials	4	8	(10)
Other (known)	16	33	(39)
Unknown	7	15	
TOTAL	48	100	(100)

*Percentage of known in brackets

Table 24A

Sources of ignition in hospital lounge fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	12	52	(57)
Television sets	3	13	(14)
Naked lights	2	9	(10)
Other (known)	4	17	(19)
Unknown	2	9	
TOTAL	23	100	(100)

Table 24B

Material first ignited in lounge fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Furniture, furnishings	9	39	(42)
Unspecified waste	4	17	(19)
Textiles	2	9	(10)
Decorations Xmas tree	2	9	(10)
Other (known)	4	17	(19)
Unknown	2	9	
TOTAL	23	100	(100)

*Percentage of known in brackets

Table 25A

Sources of ignition in laundry fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Clothes drying apparatus	7	22	(26)
Welding & cutting equipment	4	13	(15)
Smoking materials	3	9	(11)
Washing machine	2	6	(7)
Clothes iron	2	6	(7)
Mechanical heat or sparks	2	6	(7)
Other (known)	7	22	(26)
Unknown	5	16	
TOTAL	32	100	(100)

Table 25B

Material first ignited in laundry fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Textiles	14	44	(54)
Solvents, oils, chemicals	3	9	(12)
Electrical insulation	3	9	(12)
Other (known)	6	19	(23)
Unknown	6	19	
TOTAL	32	100	(100)

*Percentage of known in brackets

Table 26A

Sources of ignition in bedroom fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	8	28	(31)
Radiant heater, fire in grate	6	21	(23)
Elect. sockets & switches	3	10	(12)
Malicious	3	10	(12)
Other (known)	6	21	(23)
Unknown	3	10	
TOTAL	29	100	(100)

Table 26B

Material first ignited in bedroom fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Furniture, furnishings	20	69	(74)
Electrical insulation	5	17	(19)
Unspecified waste	2	7	(7)
Unknown	2	7	
TOTAL	29	100	(100)

*Percentage of known in brackets

Table 27A

Sources of ignition in boiler-room fires, 1967

Source of ignition	No. of fires	Percentage of fires
Central heating	6	38
Welding & Cutting equip.	2	12
Other (known)	8	50
TOTAL	16	100

Table 27B

Material first ignited in boiler-room fires, 1967

Material first ignited	No. of fires	Percentage cf fires*	
Fuel oils, paint	3	19	(21)
Lagging	3	19	(21)
Electrical insulation	3	19	(21)
Textiles, rags etc	2	12	(15)
Other (known)	3	19	(21)
Unknown	2	12	
TOTAL	16	100	(100)

*Percentage of known in brackets

Table 28A

Sources of ignition in refuse-disposal area fires, 1967

Source of ignition	No. of fires	Percentage of fires
Incinerator	16	57
Smoking materials	6	21
Naked lights	3	11
Other (known)	3	11
TOTAL	28	100

Table 28B

Material first ignited in refuse-disposal areas, 1967

Material first ignited	No. of fires	Percentage of fires*	
Unspecified waste	20	71	(74)
Structure	3	11	(11)
Other (known)	4	14	(15)
Unknown	1	4	
TOTAL	28	100	(100)

*Percentage of known in brackets

Table 29A

Sources of ignition in office fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Smoking materials	8	38	(47)
Radiant heater, fire in grate	3	14	(18)
Radio, radiogram	2	10	(12)
Other domestic appliances	2	10	(12)
Other (known)	2	10	(12)
Unknown	4	19	
TOTAL	21	100	(100)

Table 29B

Material first ignited in office fires, 1967

Material first ignited	No. of fires	Percentage of fires*	
Unspecified waste	6	28	(33)
Electrical insulation	4	19	(22)
Furniture, furnishings	3	14	(17)
Textiles	2	10	(11)
Structure	2	10	(11)
Paper etc	1	5	(6)
Unknown	3	14	
TOTAL	21	100	(100)

*Percentage of known in brackets

Table 30A

Sources of ignition in laboratory fires, 1967

Source of ignition	No. of fires	Percentage of fires*	
Bunsen burner, hot plate	6	33	(43)
Other (known)	8	44	(57)
Unknown	4	22	
TOTAL	18	100	(100)

Table 30B

Material first ignited in laboratory fires, 1967

Material first ignited	No. of fires	Percentage of fires
Electrical insulation	7	39
Solvents, oils, chemicals	6	33
Unspecified waste	2	11
Other (known)	3	17
TOTAL	18	100

*Percentage of known in brackets

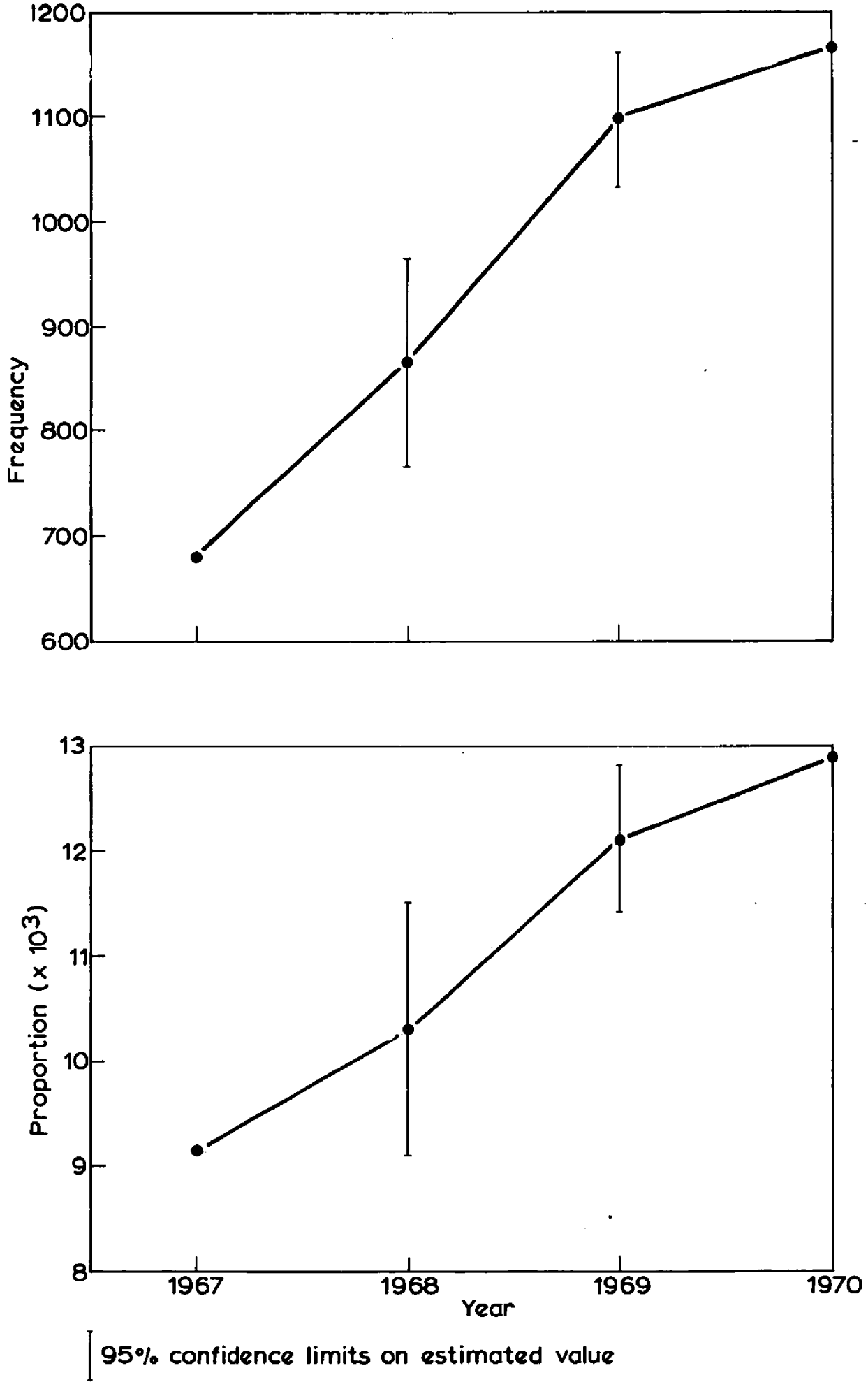


Figure 1 Fires in hospitals: frequency and as a proportion of all fires in buildings

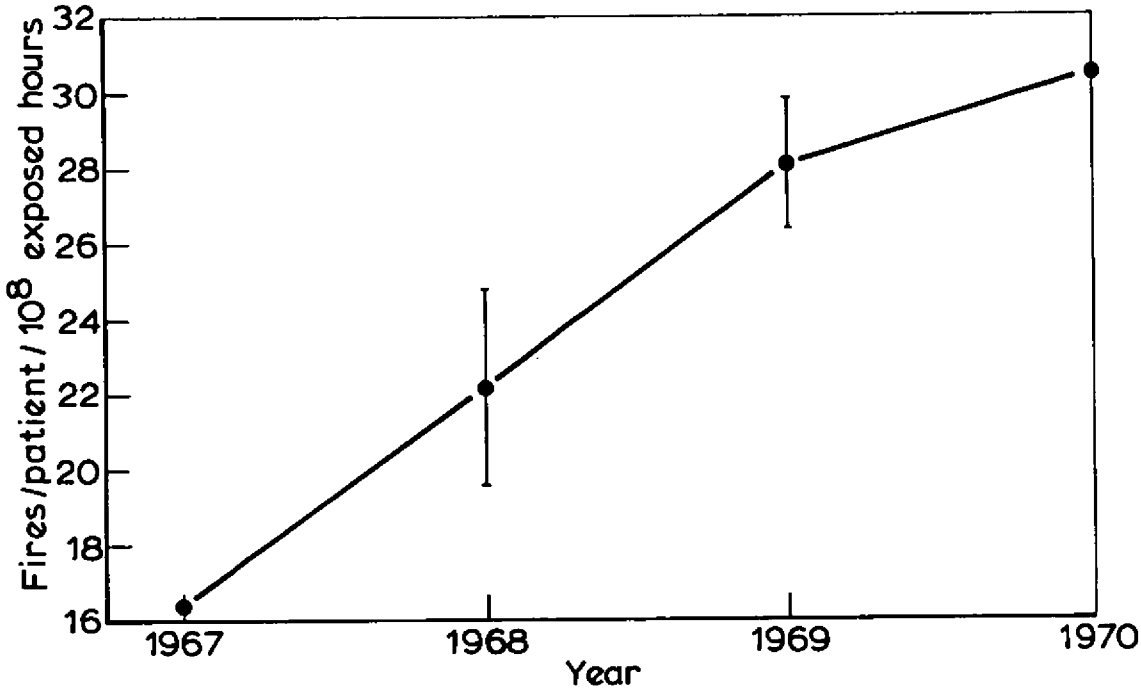


Figure 2 Hospital fire hazard rate
(Great Britain)

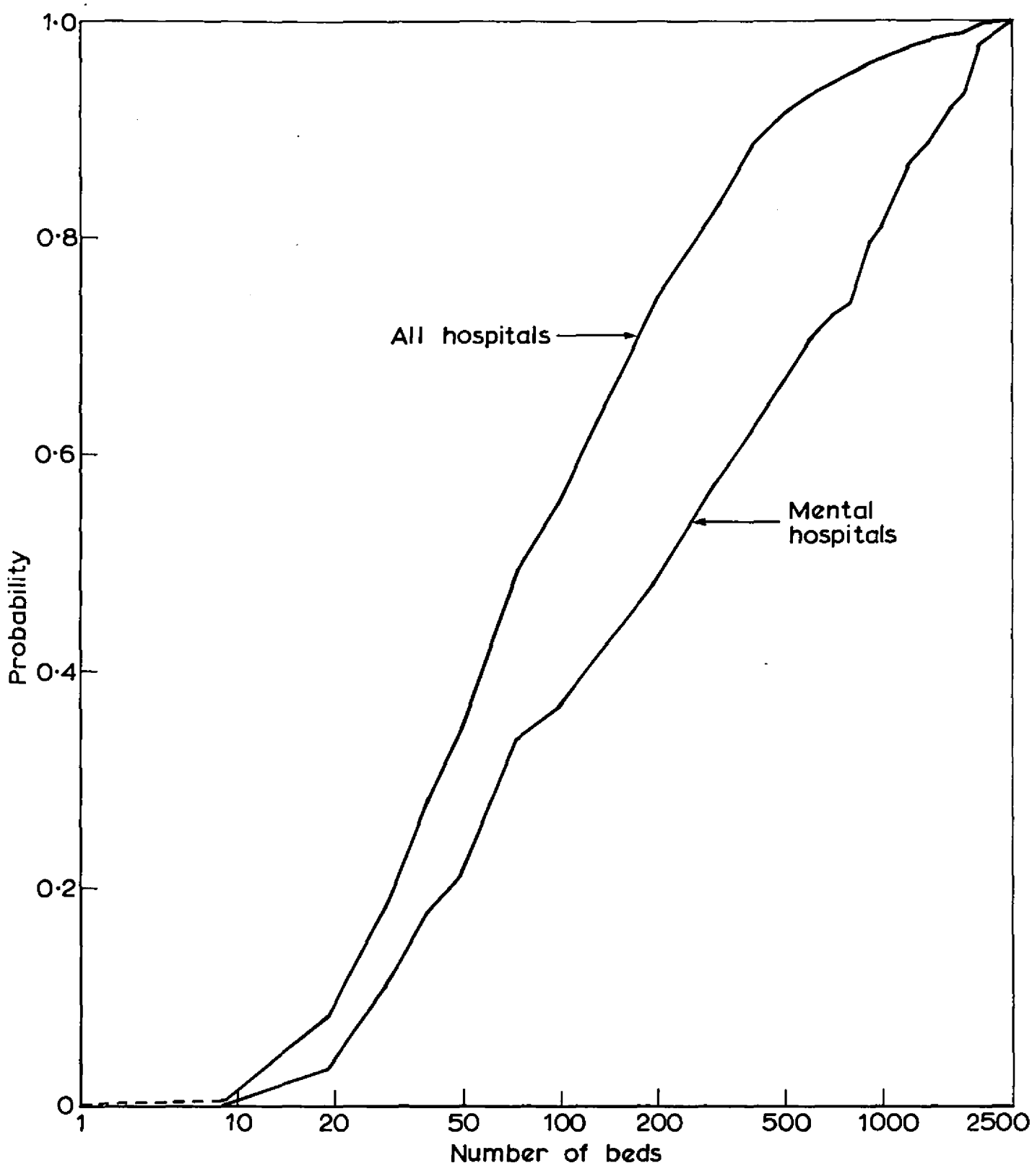
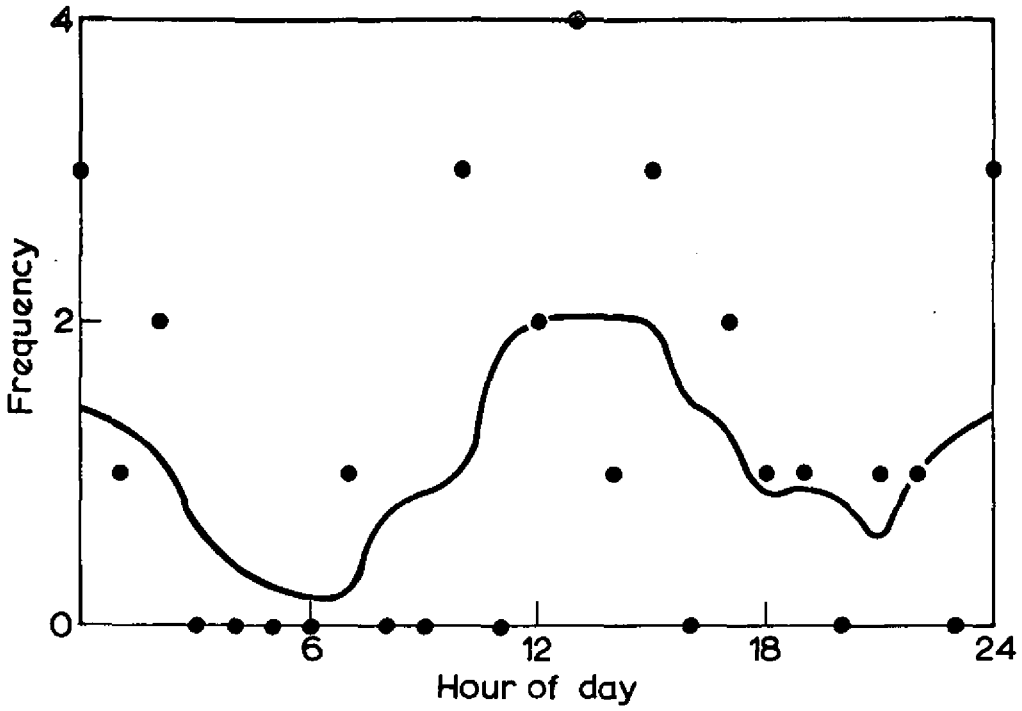
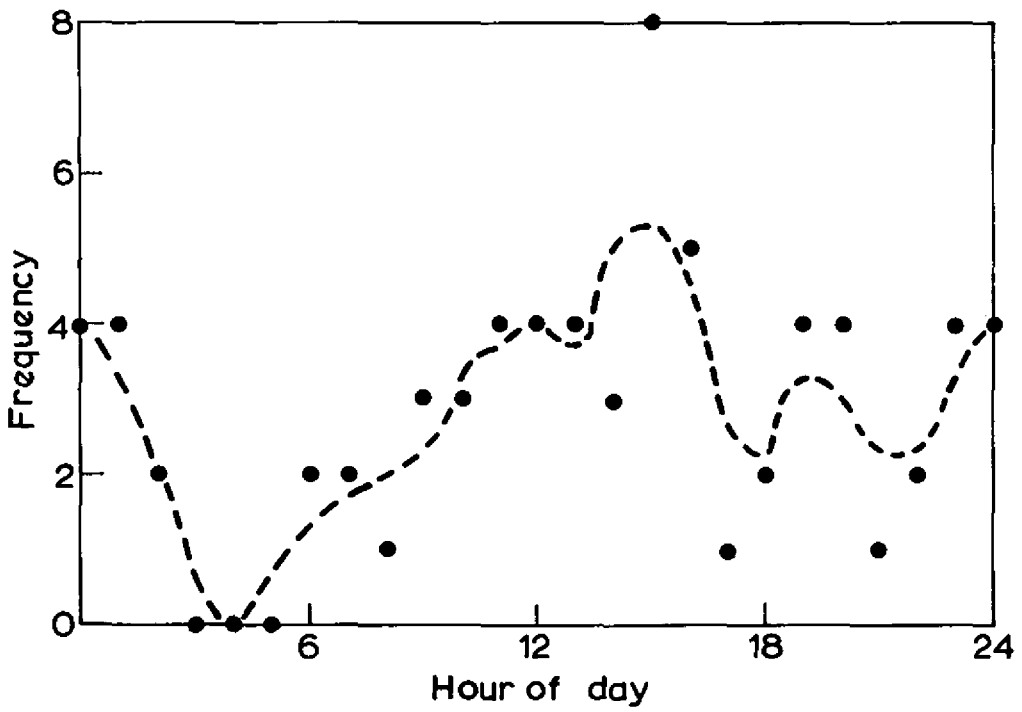


Figure 3 Cumulative distribution function of hospital sizes 1967



Fatal casualties 1967–70



Non-fatal casualties 1967-70

● Hourly frequency
—— 5 hour moving average
- - - 3 hour moving average

Figure 4 Distribution of casualty fires in time

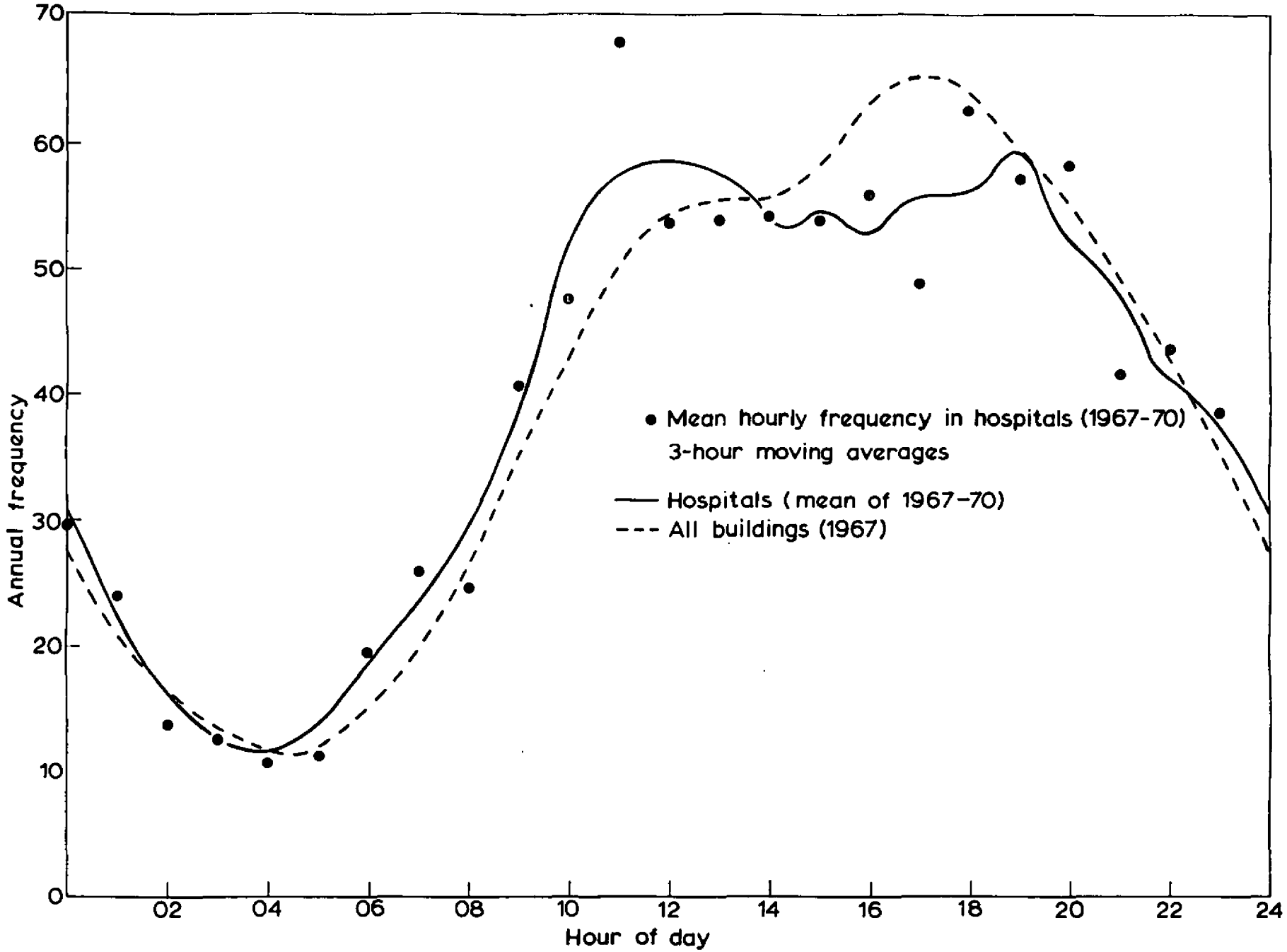


Figure 5 Time of call to fire brigade

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