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SPREAD OF FIRE IN BUILDINGS - EFFECT OF SOURCE OF IGNITION

by

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SUMMARY

The statistics of fires attended by the fire brigades show that a markedly higher proportion of fires spread beyond the room of origin when the source of ignition is either malicious or intentional ignition or burning rubbish. Other causes result in different proportions of spreading, but these differences are smaller, and in some cases could have occurred by chance statistical fluctuations.

Key words; Buildings, Fire Cause, Fire Spread, Fire Statistics, Probability.

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INTRODUCTION

"United Kingdom Fire Statistics"[1] includes data on the spread of fire in buildings in relation to the source of ignition. This data is used in the present paper to investigate whether fire spread is more likely with one source than with another as an indication of the relative hazard of fires started by the common causes, and as a possible means of identifying the causes of large fires.

The extent of fire spread is measured by a broad description of the physical boundaries of the final fire area. Thus fires are classified according to how they are confined e.g. to the room of origin, the floor of origin and the building of origin. These measures of size are not altogether satisfactory if for no other reason than the ambiguity of the meaning of "room", but they do give some indication of the size of the fire in relation to the building. Following Thomas[2] these statistics are used in the present paper to determine the chance of a fire spreading beyond the room of origin, and comparison of these values for different sources of ignition then gives a measure of the hazard of the different causes of fire, assuming there is no bias in recording cause.

CALCULATION OF THE CHANCE OF SPREAD

Table 1 gives the value of p, the chance of fire spreading beyond the room of origin, for various sources of ignition, for the years 1964, 1965, and 1966, based on "U.K. Fire Statistics" for those years (contained in Table 25A). For this purpose certain extent categories have been excluded, namely those in which fire spread to other buildings, which form only a small part of the total, and those fires confined to exterior components, the items first ignited or common service spaces, since these do not usually affect the integrity of the structure. Also excluded are the large numbers of fires in single compartment buildings since for these fires no measure of spread is available.

Table 1

Chance of fire spreading beyond the room of origin for different sources of ignition

Source of ignition	Probability of fire spread (p)		
	1964	1965	1966
Electrical appliances and installations	0.11	0.12	0.13
Gas appliances and installations	0.09	0.09	0.10
Solid fuel appliances and installations	0.11	0.14	0.14
Oil appliances and installations	0.16	0.18	0.19
Liquefied petroleum gas appliances and installations	0.20	0.24	0.21
Acetylene appliances and installations	0.21	0.19	0.13
Other and unspecified fuel appliances and installations	0.16	0.16	0.14
Smoking materials	0.14	0.15	0.14
Malicious or intentional ignition	0.41	0.38	0.41
Children with fire (e.g. matches)	0.17	0.18	0.18
Matches (except children with)	0.17	0.12	0.11
Naked light (no further information)	0.21	0.28	0.23
Spontaneous combustion	0.16	0.14	0.20
Mechanical heat and sparks	0.26	0.29	0.26
Rubbish burning	0.37	0.37	0.41
Chimney stove pipe flue (not confined to)	0.11	0.11	0.14
Explosives, fireworks	0.14	0.14	0.12
Natural occurances	0.18	0.24	0.16
Miscellaneous	0.10	0.13	0.10
Unknown	0.42	0.44	0.46

STATISTICAL ANALYSIS

Table 2 gives an analysis of variance of these data, based on the method of Bogyo and Becker[3]. This technique, which first transforms the proportions p to angles by means of the transformation $y = \sin^{-1}(p)^{\frac{1}{2}}$ then separates the mean squares shown in the Table into estimates of variance components due to differences between sources, differences between years, and a component attributable to the chance binomial variation. These components are shown in Table 3.

It is clear that there is no significant year to year variation since the component due to yearly fluctuations is less than the expected binomial variance. On the other hand the variance due to variations between different sources is very highly significant compared with the expected binomial variance, the year to year variation, or with the overall error mean square. Thus fires starting from different causes have significantly differing chances of spreading beyond the room of origin or of being reported as such: (this is especially a factor in the category "unknown").

Table 2

Analysis of variance (transformed data)

Source of variation	Mean squares	Degrees of freedom
Between sources of ignition	139.67	19
Between years	2.795	40

Table 3

Estimated variance components (transformed data)

Component	Variance
Between sources of ignition	45.625
Between years	1.339
Binomial variance	1.456

DISCUSSION

It has now been established that there are significant differences between the sources of ignition, but of greatest interest are those sources of ignition in which p is largest, the values for 1966 being listed in Table 4. The three highest values shown are significantly greater than the overall value for all other sources of ignition.

Table 4

Sources of ignition with the highest chance of spread (1966)

Source of ignition	Probability of spread (p)
Malicious or intentional ignition	0.41
Rubbish burning	0.41
Unknown	0.46
All others	0.14 (in the range 0.10-0.26)

The high value of p for the unknown source of ignition is most likely due to the fact that for large fires the source of ignition is very much harder to ascertain, the evidence having been destroyed by the fire. This is reflected in data on very large fires (fires fought with more than five-jets[4]) in which more than half the fires are of unknown origin. The high value of p for malicious or intentional ignition is not unexpected since a person intending to start a fire would try not to leave spread to chance. Rubbish burning is rather a newcomer to the list of hazardous causes, but it seems plausible that a large amount of rubbish would cause rapid spread.

Malicious ignition is also widely believed to be one of the principal causes of large fires, but unfortunately, because of the large number of unknown causes in large fires, the data on causes of five-jet fires is not sufficiently representative for a comparison to be made with fires spreading beyond the room of origin. Chimney fires have traditionally been regarded as fires with a low chance of spread to the rest of the building and by this standard so have fuel appliances. There is a need, however, to break down the figures into finer sub-divisions.

CONCLUSIONS

There is evidence that the source of ignition of a fire has a significant effect on the chance of a fire spreading beyond the room of origin. Fires started by malicious or intentional ignition, or by rubbish burning have about three times the chance of spreading as those started from other types of cause.

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REFERENCES

1. United Kingdom Fire Statistics, 1964, 1965, 1966. Ministry of Technology and Fire Offices' Committee Joint Fire Research Organization. London. H.M. Stationery Office.
2. THOMAS, P. H. The spread of fire in buildings: a statistical approach. Joint Fire Research Organization Fire Research Note 694/1967.
3. BOGYO, T. P. and BECKER, W. A. Biometrics, 1965, 21 1001-7.
4. DUNN, JENNIFER E. and FRY, J. F. Fires fought with five or more jets. Fire Research Technical Paper No. 16. London, 1966. H.M. Stationery Office.