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annuity-certain would be subject to deduction of income-tax on its whole amount, and then formula v would be applicable.

The only difficulty in using formulas iii and v is, to fix the value of *t*.   In former times it was not unusual, in calculations of various kinds, to assume an average rate of 1*s*. in the £, which was thought to be on the safe side, but at the present day the safety of that course would appear to be doubtful.

" The possible Association of the Consumption of Alcohol with Excessive Mortality from Cancer." *   *By* ARTHUR NEWSHOLME, M.D., F.R.C.P. LOND., *Medical Officer of Health of Brighton.*

PART II of Dr. Tatham's decennial supplement to the 55th report of the Registrar-General, published in 1897, contained extremely valuable statistics relating to the relative death-rates and what are known as the "comparative mortality figures" of men engaged in different occupations.   These statistics dealt not only with deaths from all causes in conjunction, but also from certain diseases ; and the latter figures throw important light upon the influence of occupation on the mortality, for instance, from tuberculosis and cancer.

In commenting on these figures in 1899[1] I drew attention to the fact that the comparatively low mortality figure for medical men (43) and other instances which were adduced did not lend support to the theory that excessive mental strain and anxious work provoked cancer.   The following remarks were added : " The low cancer figure " for coal miners (38) indicates that they enjoy a relative immunity " from cancer as well as from phthisis.   Can any reasonable hypothesis " be framed to explain why the manipulation of coal underground " should be so much less irritating than its manipulation overground ? " (coal-heavers' comparative figure 56).   *Can it be that we have to* " *look to intemperate habits as being a main factor at work rather* " *than the particular occupation ?*   The figures for commercial " travellers (63), coachmen and grooms (58), seamen (60), brewers (70), " innkeepers (53), ditto in London (70), and butchers (57) certainly " point in this direction.   The figures for chimney sweepers (156) " appear, however, to stand in a separate and independent category."

My attention was again drawn to the same suspicion at a later date, and in October 1902, I communicated with Mr. T. P. Whittaker, M.P., the Managing Director of the United Kingdom Temperance and General Provident Institution (spoken of throughout this paper as the Institution), and through his kindness and that of Mr. R. M. Moore, the Actuary of the Institution, the figures summarized in Tables I and II came into my hands in November 1902.   After working out the death-rates from cancer in standard populations for abstainers and non-abstainers (from alcohol) respectively, and finding that the former were startlingly lower than the latter, I postponed publishing the results, first, because of paucity of data, and secondly,

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because at the time it appeared impracticable to eliminate a fallacy arising from the unknown proportion of males and females in the sections of the Institution under comparison.

The second source of error can now be practically dismissed in the light of Mr. Moore's paper read before the Institute of Actuaries on 30 November 1903.[2] This paper gives the experience, so far as deaths from all causes are concerned, during the years 1841–1901 of 864,953 male lives at risk, of whom 398,010 were abstainers, and 466,943 non-abstainers; while the corresponding number of females exposed to risk in 1841–1901 were 34,013 abstainers and 67,056 non-abstainers. It may be added that of the females at risk, 19,777 abstainers and 42,495 non-abstainers were over 45 years of age (that is, of the special cancer ages).

The figures supplied to me gave the number of lives at risk in each of three successive quinary valuation years, 1891, 1896, and 1901; and the number of deaths from all causes, and copies of the death certificates from malignant disease were also supplied for the same years. In each set of figures ages were given, and in the mortality figures sex was also indicated.

From these data Table I has been prepared. It will be noted that the abstainers' section is somewhat larger than the non-abstainers' section; but if 45 and over be taken as the special cancer age, then the number of years of life at risk is 27,411 in the abstainers' and 29,968 in the non-abstainers' section.

The last two columns in Table I deal with deaths from cancer. The total number of deaths from cancer given in this table is 125. But the total number of deaths from cancer in the death returns for these three years was 146. The 21 excluded are deaths of females from cancer. This exclusion obviously needs justification. Either exclusion or inclusion is a possible source of error, as the number of female lives at risk in these three years, classified according to age, was unascertainable. Now, during 1841–1901 the proportion of male to female lives at risk was as 8 or 9 to 1; the proportion of abstainers to non-abstainers was among men as 398 is to 467, among women as 34 is to 67. It is, I think, fair to assume that the same proportions of men to women and of abstaining to non-abstaining women holds approximately good for the figures in Table I. Among the women included in the lives at risk in this table 21 deaths from cancer occurred. It is well known that the registered mortality from cancer is much higher among women than among men. Thus in 1901 the death-rate from cancer per million living aged over 35 years, corrected for differences in the age-constitution of the respective populations, was 2·12 among men and 2·90 among women in England and Wales.[3] Consequently, if the 21 deaths from cancer among women were left in Table I without a corresponding statement (unobtainable) of the female lives at risk a considerable error would arise. On the other hand, by leaving the female lives at risk out of the same table the death-rate among men in the two sections will be understated. This is of minor importance if the proportion between the two sections is not disturbed. Such freedom from disturbance cannot be secured; but it can be secured that the disturbance shall influence results towards a conclusion opposed to that which will be eventually reached.

The distribution of the 21 female deaths from cancer was 3 in the abstainers' and 18 in the non-abstainers' section. But we have seen that the proportion of female abstainers' lives was to female non-abstainers' lives as one to two (34 to 67). It follows that by altogether excluding the female deaths from cancer, and leaving in the female lives, the abstainers' section is unfairly handicapped in comparing its experience respecting cancer with that of the non-abstainers' section.

The first source of error—that involved in the paucity of the data—will be discussed later.

<div align="center">TABLE I.</div>

Ages of Insured Persons or of Persons Dying in each Group	AGGREGATE POPULATION OR YEARS OF LIFE AT RISK IN THE THREE YEARS 1891, 1896, AND 1901		DEATHS DURING THE THREE YEARS 1891, 1896, AND 1901			
			From All Causes		From Malignant Disease in Males	
	Abstainers' section	Non-Abstainers' section	Abstainers' section	Non-Abstainers' section	Abstainers' section	Non-Abstainers' section
Under 24	1,490	321	4	...	...	...
25–34	5,926	2,980	13	20	...	...
35–44	10,184	7,055	44	52	1	4
45–54	11,884	10,764	120	149	14	12
55–64	9,182	10,882	170	283	13	25
65–74	4,912	6,500	227	399	13	33
75 & upwards	1,433	1,822	180	269	6	4
	45,011	40,324	758	1,172	47	78

From the data given in Table I it is desired to obtain the death-rate in each section from all causes and from cancer respectively. This can be stated in terms of the number living at each age-period 25—, 35—, 45—, &c. ; and this is the method adopted in Mr. Moore's paper referred to above. This method, however, does not give the *ideé d'ensemble* secured by the method adopted in Table II, and is open to objection, as regards cancer, that the number of deaths at each age-period is too small to be free from accidental variations. In Table II the number of deaths occurring among the lives at risk at each age-period being given, the number that would occur in a standard million, aged 25 and upwards, is calculated. By this means death-rates in a standard population, aged 25 and upwards, are obtained, which are strictly comparable. The standard population chosen for this purpose is that of the English Life Table No. 3, Persons, in order that the results may be comparable with those given by Mr. George King, F.I.A., and the present writer.[4] In Table II, as printed, only the cancer death-rates are given, but similar rates were calculated for deaths from all causes. *The death-rate from all causes in the three years* 1891, 1896, *and* 1901 *was* 17·13 *among the abstainers and* 23·52 *per* 1,000 *lives at risk among the non-abstainers;*

while the death-rate from malignant disease was 0·95 *among the former and* 1·34 *per* 1,000 *among the latter. In other words, if the death-rate among non-abstainers in each instance be stated as* 100, *that of abstainers from all causes was* 72·8, *and from cancer was* 70·9.

The italicized sentences give the main conclusion to be derived from Tables I and II. In discussing the validity of this conclusion we must revert to the already mentioned fallacy of paucity of data, and consider whether, apart from this, the abstainers' and non-abstainers' sections are truly comparable.

<div align="center">TABLE II.</div>

Death-rate per Standard Million in (A) *Abstainers' and* (B) *Non-Abstainers' Section of the United Kingdom and General Provident Institution from Cancer.*

A.—ABSTAINERS' SECTION.						
Age	Number Lives at Risk	—	Number in a Standard Million of Population	—	Actual Number of Deaths from Cancer among the Lives at Risk	—	Calculated Number of Deaths from Cancer
25	5,926	is to	260,259	as	0	is to	0
35	10,184	,,	232,106	,,	1	,,	22·8
45	11,884	,,	199,912	,,	14	,,	235·5
55	9,182	,,	158,812	,,	13	,,	224·8
65	4,912	,,	102,196	,,	13	,,	270·5
75 & upwards	1,433	,,	46,715	,,	6	,,	195·6
	43,521	,,	1,000,000	,,	47	,,	949·2

B.—NON-ABSTAINERS' SECTION.						
25	2,980	is to	260,259	as	0	is to	0
35	7,055	,,	232,106	,,	4	,,	131·6
45	10,764	,,	199,912	,,	12	,,	222·9
55	10,882	,,	158,812	,,	25	,,	364·9
65	6,500	,,	102,196	,,	33	,,	518·8
75 & upwards	1,822	.,,	46,715	,,	4	,,	102·6
	40,003	,,	1,000,000	.,	78	,,	1,340·8

The labour involved in extracting the death certificates was so great that returns for only three years could be obtained. These dealt with a population at risk of 85,335 persons, among the predominant male portion of whom 125 deaths from cancer occurred. It is possible that the next series of extracts would give somewhat different results. It is highly improbable that they would go far

towards transposing the two cancer death-rates. The trustworthiness of this small basis of cancer death-rates is confirmed by the corresponding death-rates for all causes. As already stated, Mr. Moore has compared death-rates from all causes among abstainers and non-abstainers for 60 years, including 864,953 male lives at risk. These are not given for standard populations as in Table II, but for each quinary age-period separately. Taking the ages 35 to 75 the ratio of the non-abstainers' to the abstainers' mortality varies from 100 to 54·8 up to 100 to 86·5. The proportion between the abstainers' and non-abstainers' general death-rate is, therefore, not very different from that during the three years in Table I, and it is reasonable to suppose that the same proportion would be likely to hold good for cancer if this could be tested. The figures as to cancer, however, indicate the necessity for further investigation on the same lines, and do not justify any dogmatic conclusion until this further statistical investigation has been made. It should be noted, also, that the ratio of the abstainers' to the non-abstainers' death-rate is almost identical, whether the total death-rate or the death-rate from cancer be taken. It cannot therefore be claimed, assuming that more extensive data confirm those in Tables I and II, that alcohol has a greater influence in increasing the death-rate from cancer than in increasing that from the aggregate of other causes of death.

Such a remarkable difference in the corrected death-rate from all causes and from cancer among abstainers and non-abstainers respectively, suggests the desirability of ascertaining whether the data are untrustworthy, either by transfer of lives from one section of the Institution to the other, or because of other sources of error. From Mr. Moore's paper we learn (p. 215) :

" Persons are eligible for the temperance (abstainers') section who " do not take alcohol as a beverage in any form. The continued " adherence of the assured to the principles of abstinence is checked by " an annual declaration to that effect . . . People who do not come " within these conditions are eligible for the 'general section' only, and " are herein described as 'non-abstainers.' If an abstainer cease to " abstain he is transferred to the general section; and on the other " hand, assurers in the general section who become abstainers " are generally eligible for transfer to the temperance section. " The effect of these 'transfers' on the mortality of the two " sections respectively will be dealt with later on in this paper, but it " may be here stated that such transfers are not made if the assurers " be known to be in bad health or of intemperate habits, and transfers " from the temperance section are not made in the cases of persons over " 70 years of age. Moreover, the 'transfers' are few in number."

Mr. Moore adds : "The same care is exercised in admitting a new " assurer into either section as regards family history and personal " condition. But possibly if there were any unfavourable information " on either of these points the case may have a better chance of " acceptance if the life be an abstainer. It should thus be made clear " that the temperance section has never been favoured or nursed with " the view of securing more favourable mortality results, either by the " admission of unexceptionable lives only in the first instance or by the " removal or transfer of inferior or doubtful lives."

The same point is further dealt with on p. 238 *et seq.* of the same paper, in which Mr. Moore answers the suggestion that " when " an abstainer's health deteriorates, if he takes alcohol, he is transferred " to the non-abstainers' section to die, and his death is included in the " latter section." On this point Mr. Moore says : "Now (*a*) an " abstainer is allowed to take alcohol temporarily as a medicine *bonâ* " *fide*, and (*b*) he is not transferred if he be known to be in bad health " or of intemperate habits. (In the latter case (*b*) a record is made " in the Institution's registers that he is to receive non-abstainer's rate " of bonus only). But, apart from these facts, the transfers have been " so few that their effect can be but insignificant."

Table XV in Mr. Moore's paper shows that during the period 1847–1901, only 2,685 transfers to non-abstainers and 1,465 to abstainers occurred. These form a very small percentage of the total number of lives at risk, and by experimental tables combining the experience of the transfers with that of the non-abstainers and of the abstainers respectively (Tables XVIII and XIX in his paper), Mr. Moore is able to establish satisfactorily that the superiority of the abstainers' over the non-abstainers' section has not been brought about by the operation of the "transfers ", and that, in fact, this element in the problem may be dismissed from consideration.

Nor can it be said that the non-abstainers come from any stratum of society distinct from that supplying the abstainers. The average sum assured in the two groups is approximately equal throughout the whole experience.

There appears, therefore, to be good reason for accepting the above death-rates from cancer in the two sections as stating, subject to the remarks on paucity of data, the true relative position of the two, or at least as not understating the mortality among the abstainers. In view of the preceding remarks about the 21 deaths from cancer among women insured in the Institution, the relative mortality from cancer among the abstainers is possibly overstated.

It may be added that among the 125 deaths from cancer, 4 male deaths in the abstainers', 4 male deaths in the non-abstainers' section, and no female deaths, were certified to be due to sarcoma. These deaths have not been excluded, and it is likely that a number of other deaths from cancer were due to sarcoma and not to carcinoma. This pathological source of error is inherent in nearly all cancer statistics available, and in those contained in Table I like the rest. There is, however, no apparent reason why this error will differ in the two classes compared.

The cancer statistics of the Institution were further analyzed as to site of cancer ; but the figures thus obtained did not indicate any special irritating effects of alcohol on the œsophagus or stomach. The influence of alcohol in favouring or provoking cancer, if any, must be chiefly an indirect one. The view suggested by the figures in Table I is supported by occupation statistics of the Registrar-General and by other figures tabulated in Germany. Evidently, however, if alcohol exerts an irritating effect, this is only one of a number of conditions favouring cancer, and alcohol cannot be elevated to the position of a primary cause. This is at present unknown.

The Directors of the United Kingdom Temperance and General

Provident Institution and of similar associations would be conferring a public boon if they gave facilities for the investigation of their experience as to cancer on a large scale.

REFERENCES.

[1] The Statistics of Cancer, *Practitioner*, April 1899, p. 379.   [2] *On the Comparative Experience among Assured Lives of Abstainers and Non-Abstainers from Alcoholic Beverages*, by Mr. R. M. Moore (*J.I.A.*, vol. xxxviii, p. 213). [3] 64th Ann. Rep. of Registrar-General of England and Wales, p. lxii. [4] On the Alleged Increase of Cancer, by Geo. King, F.I.A., and A. Newsholme (*Proc. Royal Soc.*, vol. liv, and *J.I.A.*, vol. xxxvi, p. 120).

ACTUARIAL NOTE.

On Joint Life Annuities. By H. W. Curjel, M.A.

On pages 208 *et seq.* of the *Text-Book*, Part II, an approximate method of determining joint life annuities where at least one of the lives is under 28 is given, which yields good results down to age 15; accurate results for ages down to 10 can, however, be obtained with little labour by the help of the tables given below, which are calculated at 3 per-cent. The method is applicable to any table in which l_x is the sum or difference of two corresponding terms of two series which follow Makeham's Law, if the value of the constant c is the same in both (*vide J.I.A.*, vol. xxxii, p. 309).

In Mr. King's graduation of the H^M Table, let $l_x = \lambda_x^{(1)} - \lambda_x^{(2)}$, where $\lambda_x^{(1)} =$ the number living according to the normal series and $\lambda_x^{(2)} =$ the number living according to the complementary series; then $\lambda_x^{(1)} = k s^x g^{c^x}$ and $\lambda_x^{(2)} = \kappa \sigma^x \gamma^{c^x}$, and we have

$$l_{xy} a_{xy} = \lambda_{x\ y}^{(1)(1)} a_{x\ y}^{(1)(1)} - \lambda_{x\ y}^{(2)(1)} a_{x\ y}^{(2)(1)} - \lambda_{x\ y}^{(1)(2)} a_{x\ y}^{(1)(2)} + \lambda_{x\ y}^{(2)(2)} a_{x\ y}^{(2)(2)}$$

or
$$a_{xy} = \frac{\lambda_{x\ y}^{(1)(1)}}{l_{xy}} a_{x\ y}^{(1)(1)} - \frac{\lambda_{x\ y}^{(2)(1)}}{l_{xy}} a_{x\ y}^{(2)(1)} - \frac{\lambda_{x\ y}^{(1)(2)}}{l_{xy}} a_{x\ y}^{(1)(2)} + \frac{\lambda_{x\ y}^{(2)(2)}}{l_{xy}} a_{x\ y}^{(2)(2)}$$

Now, x being $< y$, $a_{x\ y}^{(2)(1)}$ will $= a_{z\ z}^{(2)(1)}$ if $c^{z-x} = \dfrac{\log \gamma + c^{y-x} \log g}{\log g\gamma}$,

which is only slightly greater than unity, since $\log g$ is small compared with $\log \gamma$; hence $z - x$ will be small; in fact, if $y - x = 50$, $z - x = 1$. $z - x$ is tabulated in Table II.

Also $a_{x\ y}^{(1)(2)} = a_{u\ u}^{(1)(2)}$, if $c^{u-x} = \dfrac{\log g + c^{y-x} \log \gamma}{\log g\gamma}$, which is very little less than c^{y-x}; hence $y - u$ is very small, in fact, for the maximum value of $y - x (= 19)$, $y - u$ is less than ·01, and may therefore be ignored and we may write $u = y$. If ww are the equal ages equivalent to xy as determined by the seniority table