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Exploring Patterns and Trends with Selected Cancer Rates Reported by China National Cancer Registry: Alternative Perspectives and Findings

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Authors' contributions

This work was carried out in collaboration between all authors. Author TZ performed the data analysis and wrote the first draft of the manuscript. Authors Jing Cheng and Jing Chai managed the literature review and revised the manuscript. Author RF extracted the data and designed the figures. Authors DW and YS conceived the study and finalized the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Background: National cancer registration reports provide huge potential for identifying patterns and trends of policy, research, prevention and treatment significance. Yet given the range of factors involved in cancer onset, case identification, progression and reporting, pin-pointing this complexity requires systematic thinking and varied strategies of data analysis.
Methods: The study extracts data about incidence rates (IRs) and mortality rates (MRs) of lung, stomach, colorectal and liver cancers for 2004, 2006 and 2009 from relevant China National

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Cancer Registry (CNCR) reports and analyzes the data using line-graphs, ratios and logistic growth modeling.

Results: The study shows that: a) all line graphs of age-specific IRs and MRs of the 4 cancers characterized typical S-shape with substantial differences in terms of smoothness, height and proximity; b) MR lines mimicked and located below the corresponding (of the same cancer, population group and year of reporting) IR lines for almost all the age groups except 1 to 2 oldest ones; c) colorectal cancer witnessed the lowest MR/IR ratios on average followed by gastric and lung cancers and all such ratios featured an increasing trend along the age spectrum; d) urban vs. rural ratios in IRs or MRs showed an increasing trend along the age axis for 3 out of the 4 cancers but a typical v-shaped curves for stomach cancer; e) the lines of recent vs. early ratios in cumulative IRs or MRs for urban areas located apparently closer than that for rural areas; f) all the age-specific IRs and MRs fitted very well with logistic growth models (goodness of fit> 0.91) and the integrations and ages when the models reached 5%, 50% or 95% of their highest values yielded interesting features.

Conclusion: The study provides useful perspectives for analyzing age-specific IRs and MRs and reveals a number of interesting patterns and trends with cancer counts reported by CNCR.

Keywords: Cancer; registry; incidence; mortality; urban; rural.

1. INTRODUCTION

Cancer registry (CR) is gaining recognition worldwide [1,2]. Many countries, including China, have established large scale long-term operating CR systems [2-4]. These systems have accumulated large amount data about incidence rates (IRs) and mortality rates (MRs) of combined and specific cancers and thus a huge potential for identifying patterns and trends of policy, research, prevention and treatment significance [4-8]. However, most CR data are published in raw dataset with primitive groupings or summary reports (usually at an annual base) falling far short from exploring their full potential. Up to date, CR data have been used mainly in describing cancer distribution among different groups, assessing or predicting cancer burdens, and modeling age, cohort and time (APC) effects on cancers [9-12]. In addition to these, CR data may be used in many other ways. In a previous paper [13], we tried to identify some of the patterns and trends with the IRs/MRs of all cancers behind available reports published by China National Cancer Registry (CNCR). The paper addressed several features with age-specific IRs/MRs reported by CNCR and possible contributing factors. These included: S-shaped age-specific IRs/MRs; identical patterns between MRs and IRs along the age spectrum; positive differences in age-specific IRs and MRs (i.e., IR minuses MR) for almost all the age groups but the oldest couple ones (i.e., 80-84 and 85 years plus); big discrepancies between the secondary peaks of age-specific MR/IR ratios for urban and rural females; U-shaped urban versus rural ratios of age-specific IRs and MRs; mixed trends in the IRs and MRs between different years etc. These provide useful perspectives and examples for exploring the mounting data from CR and other relevant initiatives.

Cancers of different types or locations are heterogeneous in terms of causes, progression, symptoms, diagnosis, treatment and prognosis [14-17]. Collective characteristics observable with all cancers combined together may differ substantially from that of specific cancers. Therefore, this paper examines patterns and trends with incidence and mortality rates of specific cancers from similar perspectives as we adopted in our previous work and others and compares the findings between these specific cancers and that of all types of cancer as a whole. Given that the CNCR annual reports provide aggregate data on 46 specific cancers, it is impossible for us to address each of these cancers within a single paper. Instead, we had to be selective and focused on only four leading (lung, stomach, colorectal and liver) cancers. Leading cancers also mean most serious health threats and thus worth top attention for any kind of studies; while four was the largest number of cancers to be fitted into manageable figures (like Fig. 1) and tables (like Table 1).

2. MATERIALS AND METHODS

2.1 Data Source

The study used CNCR annual reports as source data. It extracted incidence and mortality rates in 2004, 2006 and 2009 from CNCR Annual

Reports 2004, 2009 and 2012, respectively. CNCR Annual Report 2004 is the earliest available report of the kind; while CNCR Aannul Report 2012, the latest one. All of the reports provide incidence and mortality counts by type of cancer, age, gender, registry site and region (urban vs. rural) etc. Due to space limit, this study extracted and analyzed only data about lung, gastric, colorectal and liver cancers (further referred to as 4-cancers) (see Appendix A). They are the four most common types of cancers in China according to CNCR Annual Report 2012.

2.2 Data Analysis

The study adopted mainly descriptive analysis. It calculated 4 kinds of indicators and portrayed their patterns and trends in line or histograms graphs using Microsoft Excel 2010. These indicators include: a) age-specific IRs and MRs by gender, region (urban or rural) and year of reporting; b) age-specific MR/IR ratios by gender, region and year of reporting; c) urban versus rural ratios in terms of age-specific IR and MR by gender and year of reporting; and d) age-,gender- and region-specific ratios between accumulative IR (or MR) reported in a later year (e.g., 2009) and that reported in an earlier year (e.g., 2006). Here, an IR or MR for a given cancer and group equals the number of the cancer incidence cases registered for the group divided by the total number of people within the group; while an MR/IR ratio, the IR in a certain year divided by the MR in the same year; an IR (or MR) ratio between urban and rural areas, the IR (or MR) of urban areas in a certain year divided by the IR (or MR) of rural areas in the same year; a accumulative IR (or MR) for a given age (say age X), sum of all IRs (or MRs) from age 0 up to age X reported in a given year. Reported IRs and MRs for some age groups (e.g., age 0 through to 25) were extremely low. This made ratios generated using these IRs or MRs vary substantially and misleading. In order to prevent such problems, the calculation of part of the indicators excluded these ages.

The study also performed a series of modeling which used SPSS version 16 as calculation tool and reported age-specific IRs or MRs as observed data and produced 3-parameter logistic growth equations using formula $P_x= p_{max}/(1+e^{b-kx})$. Where x stands for age; and P_x, cancer incidence rate for a given age x; p_{max}, the biggest cancer incidence rate for all ages; k, growth rate; while b serves as a baseline growth rate that determines the location of "the rapidly growing phase" of the growth or S-curve along the age spectrum.

In addition, the study calculated integrations of all the logistic growth equations derived via the above process, $A_{0.5MIR}$ (the age when the IR of a given cancer reached 50% of its max values), time lags between $A_{0.5MIR}$ and $A_{0.5MMR}$(the age when the MR of a given cancer reached 50% of its max) and between $A_{0.95MIR}$ and $A_{0.05MIR}$, and MR vs. IR integrations ratios (a MR vs. IR integration ratio equals the integration of an IR model for a specific subgroup divided by the integration of the MR model for the same subgroup).

3. RESULTS

3.1 Simple Line-graphs

Figs. 1a-p depicts, in line-graphs, the age-specific IRs and MRs of the 4-cancers by gender (males, females), region (urban, rural) and year of reporting (2004, 2006 and 2009) respectively (see Appendix B for detailed data). All these lines characterized atypical S-shaped curves consisting of a relatively low and stable phase from age 0 to around age 35, a rapidly growing phase from around age group 35 to75, and a final phase with slowing down increase, even slight decrease. These lines showed substantial differences in terms of smoothness, height and proximity. The lines representing IRs or MRs of lung cancer for urban males located the highest; followed by IR or MR lines of stomach cancer for rural males; and IR or MR lines of lung cancer of rural males. The IR and MR lines for rural areas witnessed greater sub-trend variations than that for urban areas. The IR and MR lines of lung and liver cancers located much closer to each other compared with that of colorectal and stomach cancers. All of the MR lines located below the corresponding (of the same cancer and year) IR lines for almost all the age groups except 1 to 2 oldest ones (i.e., 80-84 and 85 years plus).

3.2 MR vs IR Ratios

Figs. 2a-p shows, in lines again, the age-specific MR/IR ratios of 35 and older population for different subgroups in year 2009 (blue lines), 2006 (red lines) and 2004 (green lines). The y-coordinate of the lines (the ratios) ranged from 0.54 to 1.25, 0.41 to 1.60, 0.24 to 1.24, and 0.63 to 1.45 for lung, gastric, colorectal, and liver

cancers respectively. Colorectal cancer witnessed the lowest MR/IR ratios on average followed by gastric and lung cancers. All the lines showed an increasing trend from younger to older age and the pace of increase remained relatively slow until some age around 60 and then began to grow faster and faster. Greater sub-trend variations or fluctuations in the lines appeared for rural than urban areas and for females than males. For any given cancer and subgroup, the 3 colored (blue, red and green) lines displayed similar trend and intertwined together without apparent difference; yet the lines for year 2009 appeared to be somewhat smoother than the other two.

3.3 Urban vs. Rural Ratios

Figs. 3a-p presents the characteristics and trends of age-specific IRs or MR ratios for people of 35+ between urban and rural areas. These ratios varied from 0.64 to 2.57 (mean=1.26), from 0.25 to 1.04 (mean=0.54), from 0.70 to 3.15 (mean=1.75), and from 0.27 to 1.59 (mean=0.66) for lung, gastric, colorectal, and liver cancer respectively. Three out of the four cancers witnessed increasing trend in the lines (Figs. 3a-d, i-p); yet stomach cancer, atypical v-shaped curves (Figs. 3e-h). Most part of the lines for lung and colorectal cancers plotted above 1; while the main part for stomach and liver cancer lines, below 1. Greater similarities in terms of the patterns (ups and downs) and absolute values of the lines between year 2004 and 2006 than that between 2004 (or 2006) and 2009 were observable with stomach and liver cancers for all subgroups. The lines representing the most recent (year 2009) ratios located higher over that of the remaining years in stomach cancer for almost all the age and gender subgroups (Figs. 3e-h) and in liver cancer for both genders (Figs. 3m-p) and age groups under 75-79 (Figs. 3m-p). Lung cancer presented some extent of increasing gap, from younger to older age groups, between the ratio lines for different years.

3.4 Recent vs. Early Ratios

Figs. 4a-p displays the ratios of cumulative IRs reported in year 2009 vs. 2006 (blue lines) and 2006 vs. 2004 (red lines) and the ratios of cumulative MRs reported in year 2009 vs. 2006 (green lines) and 2006 vs. 2004 (purple lines). They displayed a number of interesting features: a) all the lines ended within an ratio range from 0.62 to 1.43; b) all of the red and 13 out of the purple lines ended above 1 but only half of the blue and 6 out 16 of the green lines did so; c) the four kinds of colored lines consisting the gender specific figure components for urban areas (Fig. 4, columns 1-2) located apparently closer than that for rural areas (Fig. 4, columns 3-4) and, for both gender subgroups in rural areas, most part of the blue and red lines located below 1, while green and purple lines, above 1; d) only a small part of lines demonstrated some extent of decreases from age group 35 to 85+, e.g., the blue lines of lung, stomach and colorectal cancers among rural males (Figs. 4c, g, k) and of stomach cancer among rural females (Fig. 4h), and the green lines of lung cancer among rural males (Fig. 4c) and of liver cancer among urban males and females (Figs. 4m, n).

3.5 Logistic Growth Models

Table 1 provides parametric estimates of the logistic growth models of the age-specific IRs and MRs of the 4-cancers. Goodness of fit for all subgroups was estimated as high as over 0.91. Yet, the 3 parameters defining the models showed substantial variations: P_{max} (the highest IR or MR) ranged from 56.211 (for colorectal cancer) to 772.583 (for lung cancer); b, from 6.046 (for liver cancer) to 16.532 (for lung cancer); and k, from 0.386 (for liver cancer) to 1.173 (for lung cancer). As shown in Fig. 5 and Appendix C, integrations of the IR and MR models ranged from 381.84 to 3018.49 and from 245.10 to 2852.02 respectively; while $A_{0.5MIR}$, from 43.81 to 66.86. If examined on cancer by cancer base, the IR and MR integrations witnessed greater values in males than females for all the 4-cancers and in urban than rural areas for lung and colorectal cancers; while $A_{0.5MIR}$, moderate yet consistent urban over rural difference. The time lag between $A_{0.5MIR}$ and $A_{0.5MMR}$ presented substantial variations (from -0.40 to 15.05) with longer lags for colorectal and stomach cancers over lung and liver cancers and for urban areas over rural areas. Time lag between $A_{0.95MIR}$ and $A_{0.05MIR}$ differed from 25.10 for lung cancer to 67.53 for liver cancer. The MR vs. IR integrations ratios were the highest (115.43%) for liver cancer and the lowest (59.94%) for colorectal cancer. And 8 out of these 48 ratios valued even greater than 100%.

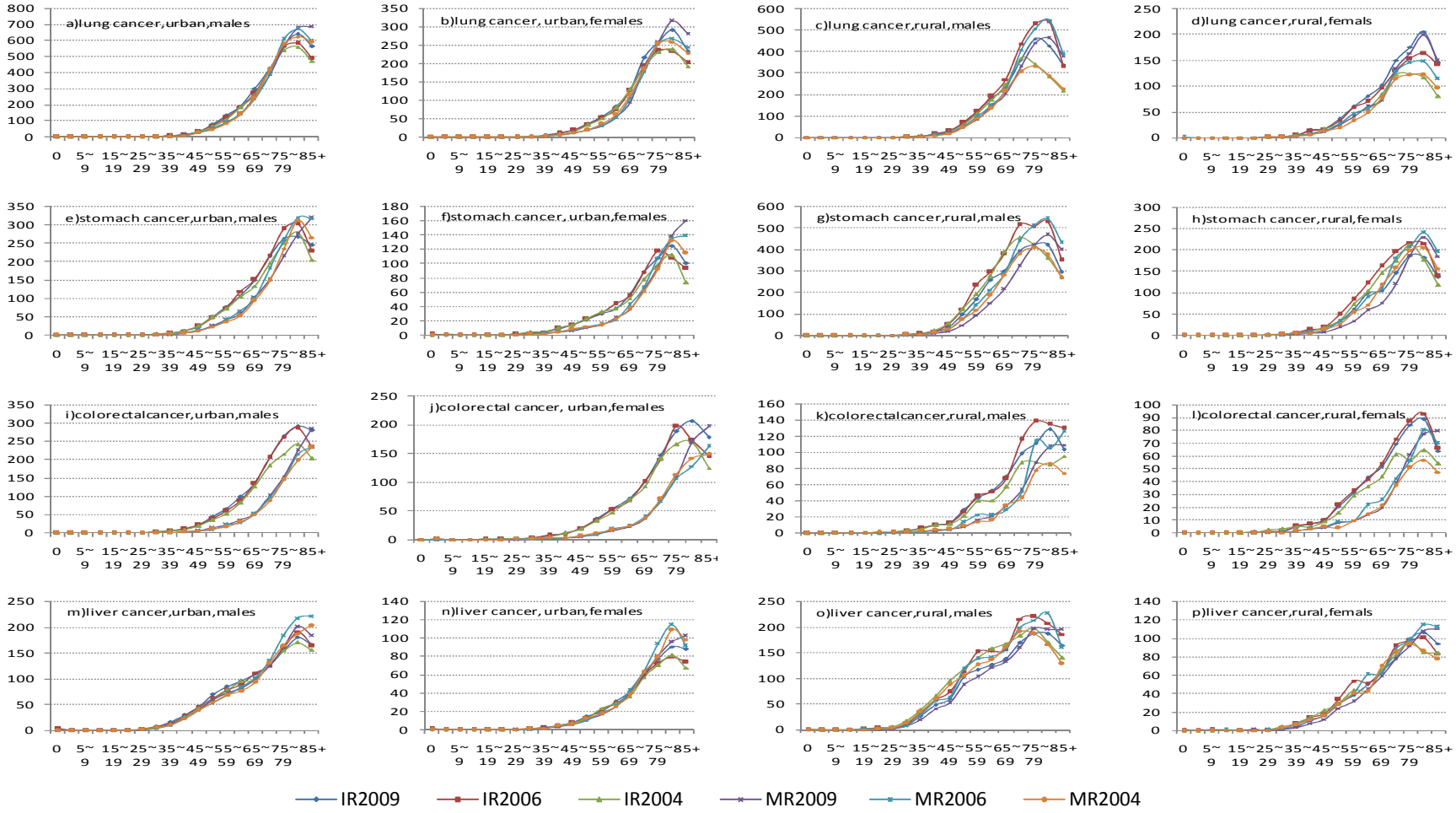

Fig. 1. Age-specific IRs and MRs by gender, region and year of reporting

Table 1. Parameters of and goodness of fit between logistic growth models and observed age-specific cancer incidence and mortality rates

Indicators	Lung cancer				Stomach cancer				Colorectal cancer				Liver cancer			
	P_{max}	b	k	R	P_{max}	b	k	R	P_{max}	b	k	R	P_{max}	b	k	R
Incidence rate																
Urban male 2009	649.37	11.59	0.77	0.99	277.10	10.47	0.73	0.99	320.93	10.01	0.66	0.99	191.98	6.05	0.44	0.99
Urban male 2006	575.18	12.63	0.85	0.98	285.95	11.28	0.78	0.97	279.22	12.09	0.82	0.98	202.28	6.25	0.44	0.99
Urban male 2004	551.71	13.20	0.90	0.99	260.97	10.40	0.72	0.97	235.79	11.71	0.80	0.99	179.99	6.48	0.47	0.99
Urban female 2009	277.99	13.14	0.89	0.98	123.58	9.99	0.67	0.98	210.59	10.08	0.68	0.99	103.39	9.22	0.60	1.00
Urban female 2006	233.73	13.49	0.93	0.98	113.30	9.80	0.68	0.94	177.44	11.08	0.78	0.97	84.62	9.81	0.66	0.99
Urban female 2004	229.95	13.45	0.93	0.98	102.14	9.01	0.63	0.95	159.46	11.37	0.81	0.97	82.28	9.50	0.64	0.98
Rural male 2009	418.84	12.54	0.88	0.97	385.44	13.21	1.00	0.97	124.68	9.13	0.64	0.98	182.38	6.95	0.58	0.99
Rural male 2006	475.30	14.65	1.03	0.94	477.92	12.82	0.97	0.96	148.45	9.81	0.67	0.98	208.48	7.37	0.63	0.98
Rural male 2004	301.95	15.76	1.17	0.95	380.81	14.90	1.16	0.95	99.46	8.78	0.62	0.99	173.37	8.12	0.75	0.98
Rural female 2009	185.96	10.20	0.72	0.97	171.58	10.79	0.78	0.97	81.74	9.64	0.70	0.97	110.14	8.04	0.57	0.99
Rural female 2006	164.03	9.42	0.67	0.99	194.54	12.97	0.98	0.96	85.29	9.76	0.71	0.97	98.94	7.97	0.60	0.98
Rural female 2004	112.26	11.87	0.88	0.95	171.52	13.93	1.05	0.95	61.67	9.86	0.74	0.99	95.09	7.67	0.57	0.98
Mortality rate																
Urban male 2009	772.58	12.39	0.78	1.00	410.91	10.09	0.60	1.00	440.44	11.07	0.62	1.00	244.26	6.31	0.41	0.99
Urban male 2006	681.88	14.88	0.96	0.99	361.67	12.81	0.80	1.00	285.35	12.94	0.77	1.00	308.56	6.67	0.41	0.99
Urban male 2004	645.87	15.00	0.98	0.99	314.68	13.96	0.88	0.98	293.52	12.33	0.72	1.00	279.94	6.29	0.39	0.99
Urban female 2009	312.00	16.36	1.05	0.99	222.36	11.04	0.64	1.00	268.28	12.40	0.71	1.00	120.46	9.95	0.62	1.00
Urban female 2006	270.40	16.53	1.08	0.99	161.63	12.49	0.77	0.99	216.06	10.72	0.62	1.00	110.77	12.56	0.82	0.98
Urban female 2004	257.93	16.40	1.09	0.99	139.41	12.79	0.79	0.98	170.34	13.22	0.81	1.00	119.77	10.51	0.66	0.99
Rural male 2009	449.58	13.62	0.92	0.98	458.80	12.35	0.83	0.99	128.85	12.04	0.74	0.99	212.40	6.40	0.48	0.99
Rural male 2006	495.89	15.82	1.07	0.96	514.37	12.68	0.89	0.98	140.45	13.08	0.81	0.96	201.98	7.39	0.62	0.97
Rural male 2004	292.86	15.66	1.13	0.97	361.36	14.95	1.09	0.96	88.00	13.16	0.85	0.97	168.35	7.68	0.69	0.97
Rural female 2009	187.09	11.70	0.78	0.97	225.36	12.51	0.81	0.98	93.84	12.38	0.76	0.99	128.59	7.99	0.53	1.00
Rural female 2006	142.52	11.16	0.79	0.97	229.85	11.72	0.80	0.98	86.89	10.48	0.66	0.98	126.94	7.57	0.52	1.00
Rural female 2004	118.46	13.38	0.95	0.98	192.81	12.71	0.89	0.98	56.21	12.98	0.86	0.97	90.57	9.02	0.68	0.98

Note: Source data came from age-specific incidence rates of top ten and all cancers from China cancer registry report 2012; P_{max}, b and k represents the parameters in the logistic equation, $yt=P_{max}/(1+e^{b-kt})$, where t stands for age and yt, incidence rate for age t; R stands for goodness of fit between predicted and observed age-specific cancer incidence rates; NA stands for not applicable

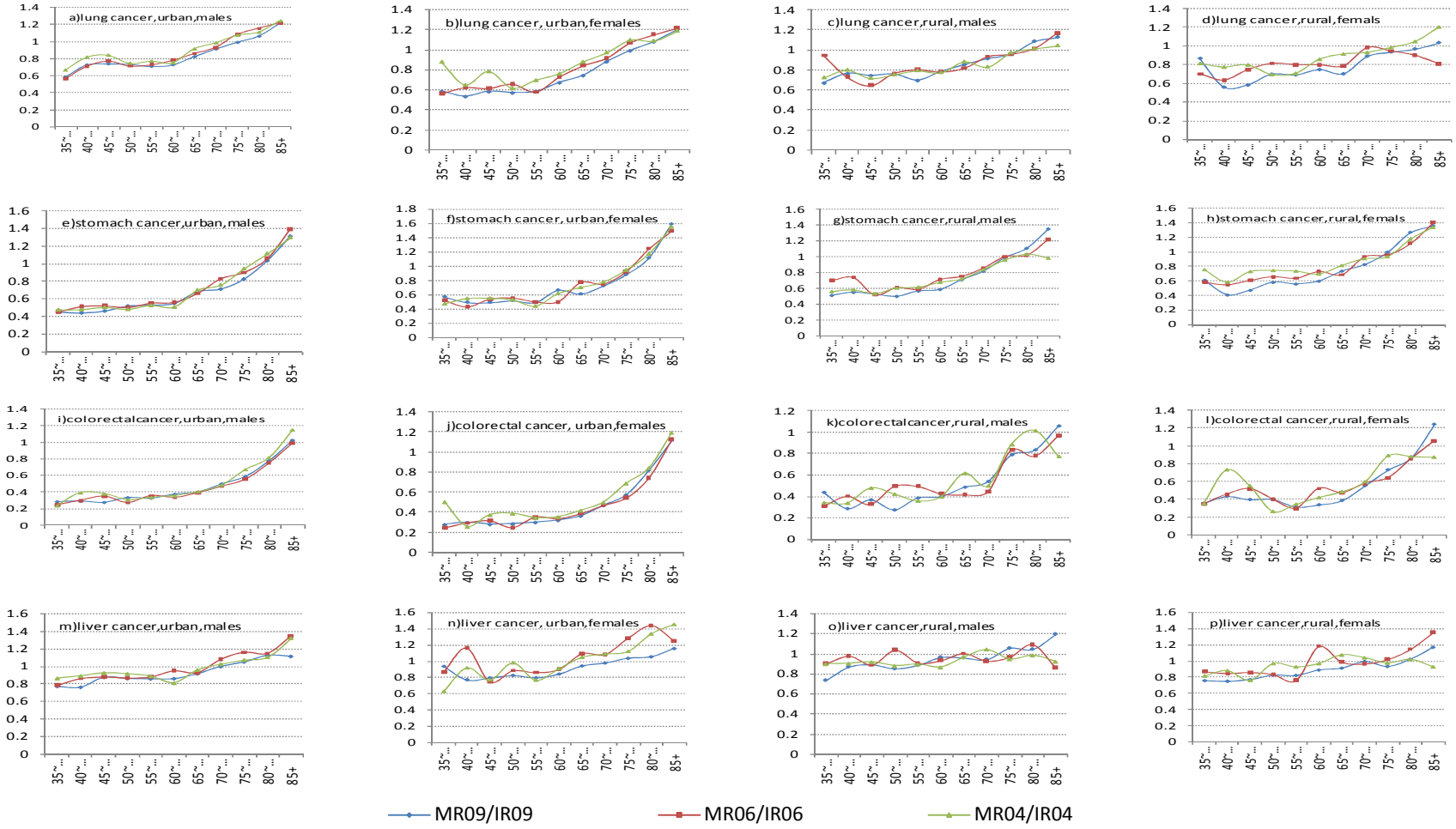

Fig. 2. MR/IR ratios by age, gender, region and year of reporting

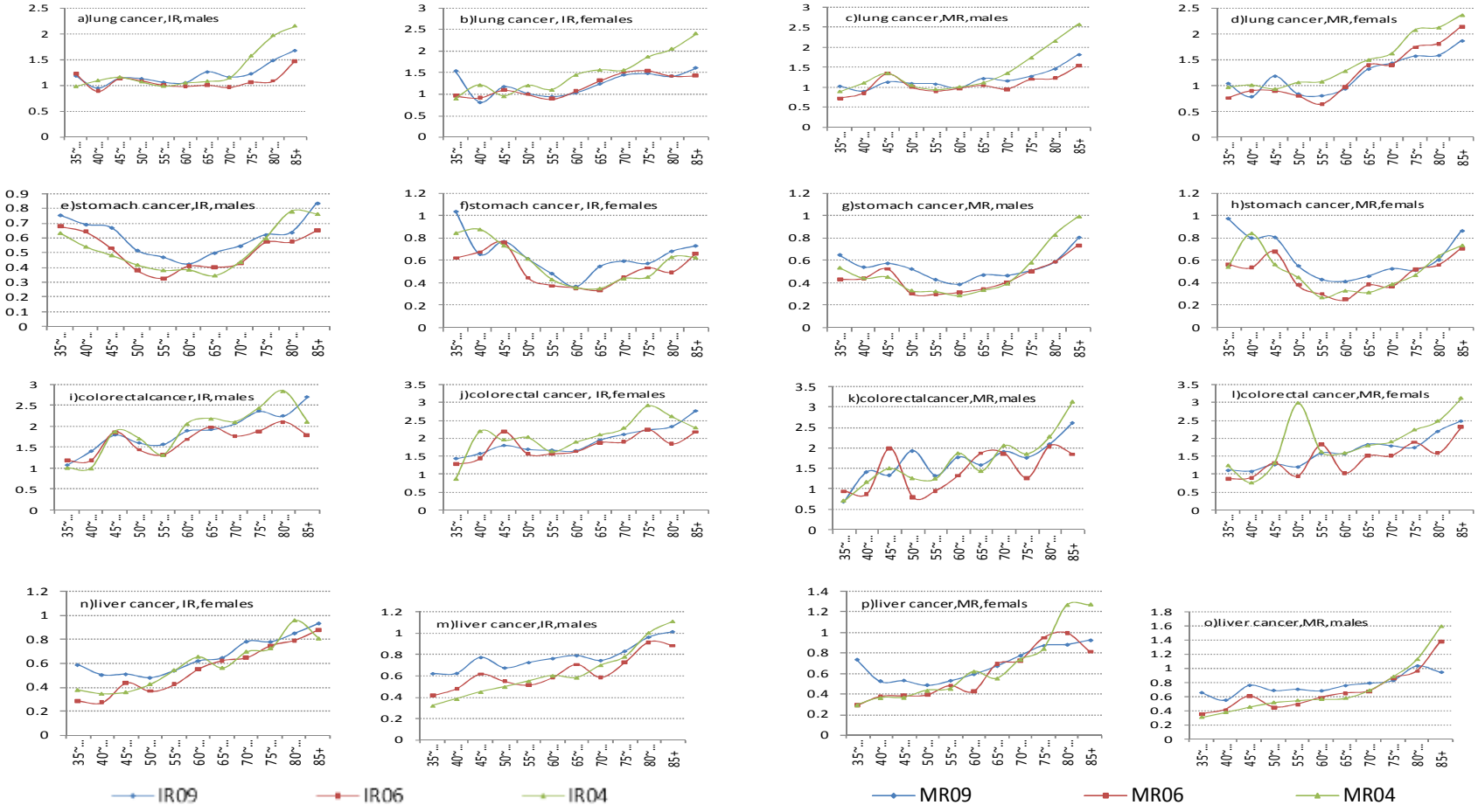

Fig. 3. Urban vs. rural ratios in IRs or MRs by age, gender and year of reporting

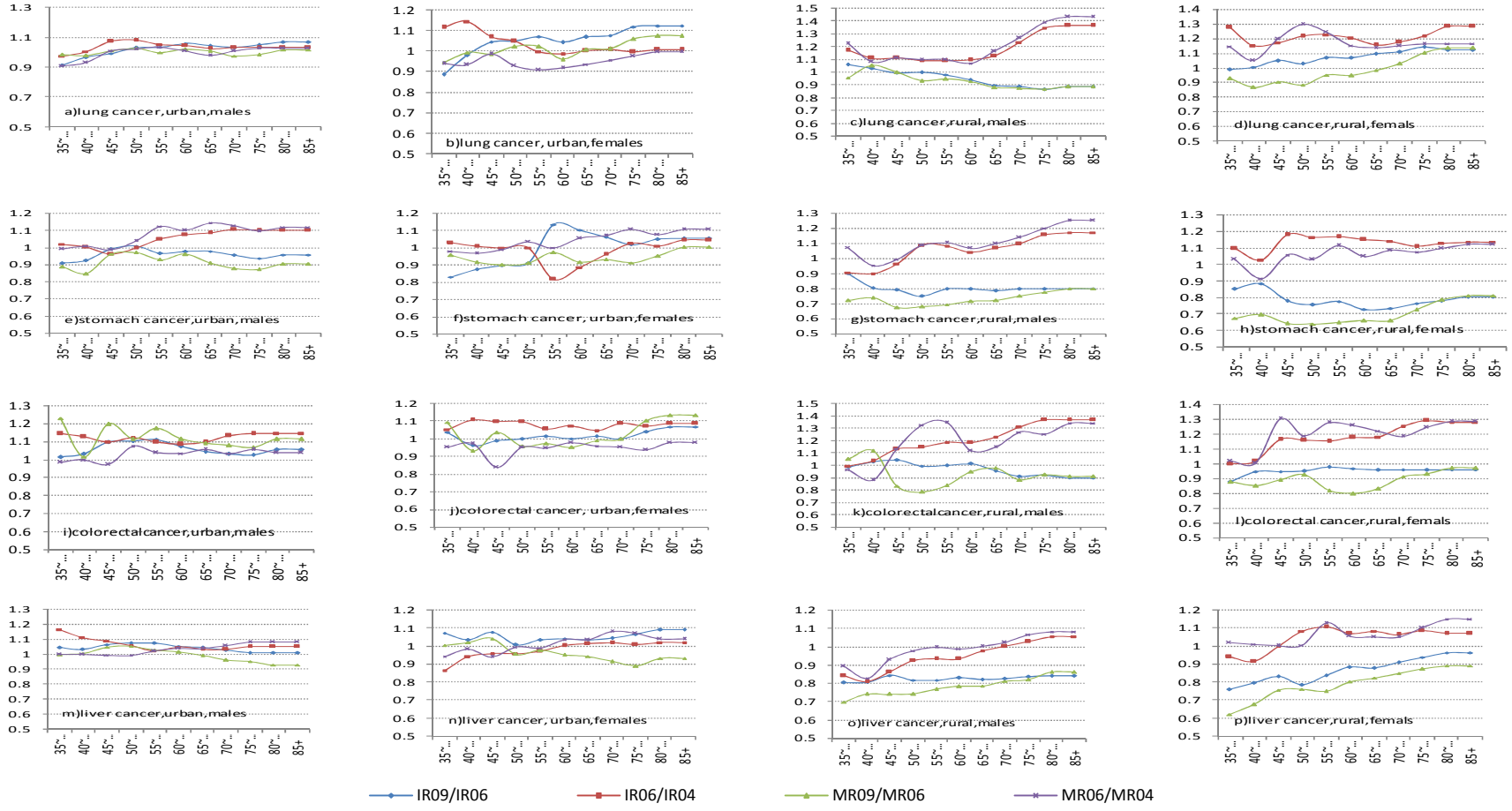

Fig. 4. Recent vs. early ratios in cumulative IRs or MRs by gender, age, and type of cancers

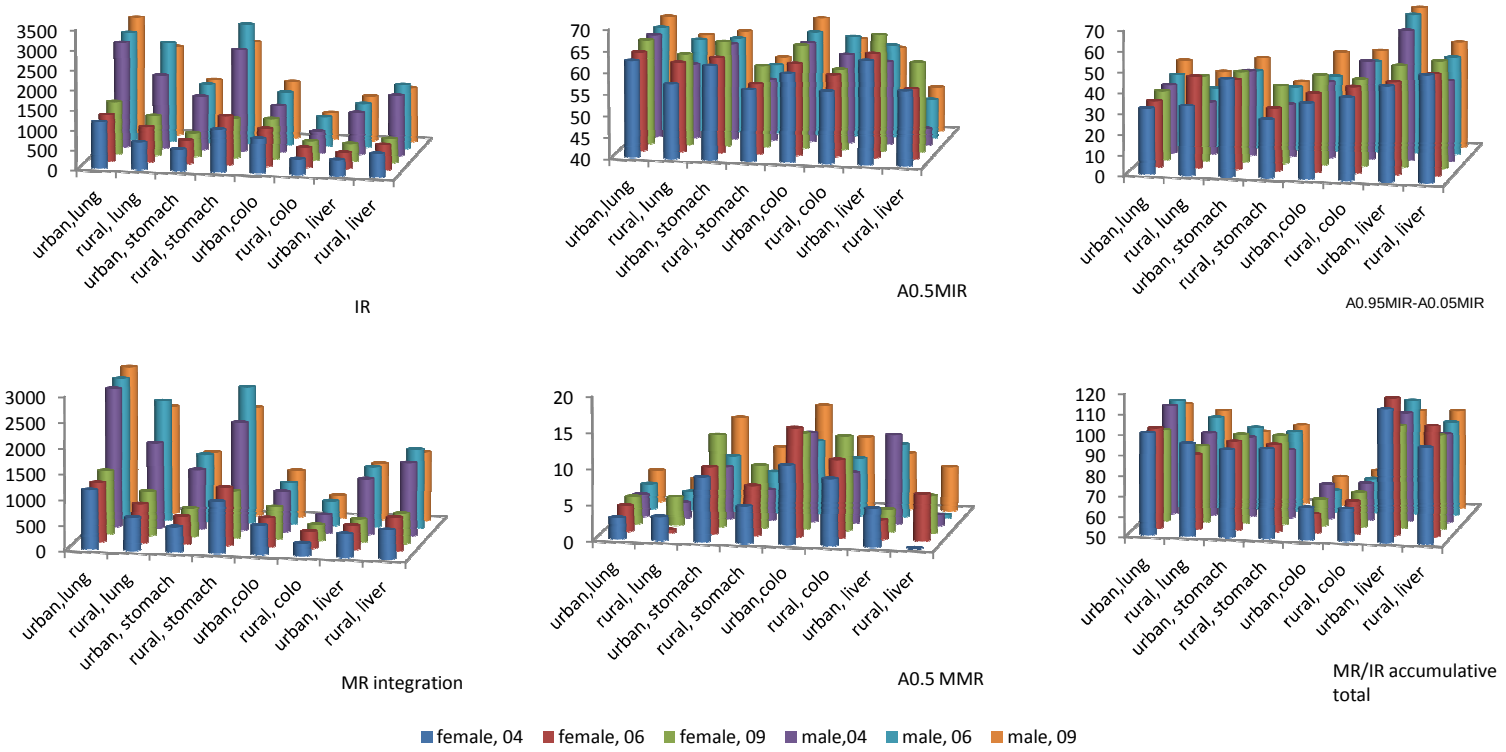

Fig. 5. Selected statistics of logistic growth modeling of the age-specific IRs and MRs

4. DISCUSSION

As more and more long-term operating cancer registry systems are being established, there is a growing need to explore the mounting data produced by these systems and inform policy-making and interventions against the epidemic. Given the range of factors involved in cancer onset, case identification, progression and reporting [18-20], pin-pointing this complexity in the path to the cancer incidence and mortality rates generated via cancer registries requires systematic thinking of all the determinants and varied strategies of data analysis. By transforming the IRs and MRs reported in the CNCR Annual Reports into four kinds of secondary indicators (i.e., patterns of age-specific IRs or MRs, ratios of MRs vs. IRs, ratios of urban IRs or MRs vs. rural IRs or MRs, and ratios of accumulative IRs vs., accumulative MRs), this study provides useful new perspectives for analyzing cancer epidemics.

Plotting age-specific IRs and MRs for different cancers, population groups and years together provides an easy yet unique comparison of the similarities and differences between: a) IRs and MRs of same cancer and year; b) IRs (or MRs) of same cancer for different years; c) IRs (or MRs) of different cancers for a given year. All the MR lines mimicked the general trend of the corresponding (of the same cancer and same population group) IR lines. This may because there is no radical cure for cancers and one incidence case occurred at age 1 generally follows one mortality case some years later (i.e., at age 1 plus years of survival of the individual under concern). The reasons why MR lines located below the corresponding IR lines may be attributed to: a) onset of cancer proceeded death due to cancer; b) IR increased as age grows; c) part of the individuals diagnosed with cancer died to non-cancer diseases and thus did not enter into cancer death registry. The drops, from age group 81-84 to age group 85+, in all the IRs and part of the MRs may be explained by reduction, due to high age, in: a) risk behaviors (e.g., smoking, exposing to poison in work); b) exposure to environmental carcinogenesis factors; c) uptake of cancer screening, diagnosis and treatment services; and d) cancer case or death reporting. Male vs. female differences in the IRs and MRs (e.g., higher IRs and MRs of lung cancer, stomach cancer, colorectal cancer, and liver cancer in males than females) may be associated with gender-related variations in genetics, physiology, psychology, lifestyles, exposure to environmental cancer genesis factors, and responses to cancer symptoms and prevention and treatment services that lead to uneven cancer registration [21-23]; while regional discrepancies (e.g., higher urban vs. rural IRs and MRs of lung cancer and colorectal cancer), different lifestyles and physical and service environments between these areas [24,25].

Ratios enable quantitative comparisons between the two indicators under concern. An age-specific MR to IR ratio is co-determined by: a) slope of trend (increase or decrease) in IRs along the age spectrum; b) survival time of the cancer under concern; c) quality of IRs and MRs reported. Therefore, the increasing age-specific ratios for all the subgroups (Fig. 2) may due largely to accelerating increases, along the age span, in all the corresponding IRs. And survival time may be a major reason for the relatively lower MR/IR ratios of colorectal cancer followed by stomach, lung and liver cancers. The finding that most of the lines in Fig. 2 increased from below to over 1 in the latest 2 to 3 age groups may not necessarily mean greater real MRs than IRs for these groups. In general, the MR of a given cancer and group should be no-higher than the IR of the same cancer and group. So the phenomenon may due mainly to reduced service utilization by and thus under diagnosis for the elderly [13].

Similarly, urban vs. rural ratios reflect the combined effects of: physical factors (i.e., heretics, immunity), environmental risks (e.g., smoking, air pollution, and sedentary work), service seeking, and case reporting (i.e., accuracy and completeness of cases and deaths reported). Differences in environment risks may be the main reasons for higher IR and MR of stomach and liver cancers and lower IR and MR of lung and colorectal cancers in urban than rural areas. Improving nutrition, drinking water hygiene and case reporting for rural residents may have played an important role in the narrowing urban vs. rural gaps in IRs and MRs of stomach and liver cancers as manifested by that the blue lines located higher over the red and green lines (Figs. 3e-h and 3m-p) [26-28]; while the decreasing discrepancies in IRs and MRs, for residents aged 70+ or so, as displayed by the apparently higher green lines over the blue or red lines in Figs. 3a-d suggest worsening relative air quality for rural residents due to escalating air pollution in rural areas and rapidly growing numbers of farmers seeking temporary jobs in cities.

Regarding ratios depicted in Fig. 4, they reflect recent vs. early (e.g., year 2009 vs. 2006) changes in accumulated burden of the 4 cancers by given age groups under concern and the ending point of each of the lines represents the relative overall burden of a given cancer among a specific subgroup. For urban areas, most of the lines representing the ratios ended above 1, suggesting a consistent increase in the overall cumulative indicators of the 4 cancers from 2004 to 2009. For rural areas, the direction of the changes seemed to be inconsistent, i.e., the cumulative IRs and MRs increased (as shown by the green and purple lines above 1) from 2004 to 2006 but decreased (as shown by the blue and red lines located below 1) from 2006 to 2009. Besides, looser lines for rural than urban areas suggest greater changes in IRs or MRs in the former 3-year period compared with that in the latter. These may be attributed to a variety of reasons. First, China started its new wave of nationwide health reforms in 2009 and began to implement the New Cooperative Medical Systems in rural areas throughout the country. Second, the CNCR Annual Report 2004 utilized data provided by 38 out of all the then 43 national cancer registries; while the 2006 report, 34 out 49 registries; and the 2009 report, 72 out of 104 registries. Third, China cancer registry system made fundamental changes in 2006 and shifted from the original 5-year reporting into annual reporting.

One point worth particular noting relates to the atypical S-shaped lines of reported IRs and MRs and their high goodness of fit with logistic growth curves for all the cancers and population subgroups. It indicates that cancer epidemic may follow logistic law. One possible hypotheses underlying this phenomenon may be: a) onset of clinically detectable cancers results from counteraction between cancer cell occurrence (determined by a threshold of multiple damages due to exposures to risk factors) and removal (determined by body immunity) [29,30]; b) as age grows, body cells get damaged for more and more times, and their chances to reach the threshold increase exponentially; c)level of life spectrum exposure to cancer risk factors starts relatively low at birth, increases during childhood and adolescence (due initiation of unhealthy or unprotected behaviors), remains the highest in adulthood and begins to decrease gradually in late lifetime (due to reduced smoking, drinking etc.) [31-33] and cancer immunity manifests similar lifetime trend [34,35]. Given these, the early low and relatively stable phase of the S-curved age-specific cancer rates may reflect the combined effects of low cancer cell occurrence vs. high immunity; while the rapidly growing part, exponentially increasing occurrence vs. high and stable immunity; and the late high and relatively stable stage, diminishing occurrence due to reduced risk exposure vs. downward immunity.

Logistic growth models may help explore age-specific cancer rates in various ways. First, description of cancer incidence or mortality rates along the whole age span using logistic growth equations becomes estimating the parameters in the equations rather than uncovering rates for all of the ages. Such a shift of focus may result in great resource reduction, since logistic equations generally involve only a few parameters and estimation of these requires much less data than what have usually been collected. Second, if there are sufficient evidences to believe that certain age-specific cancer rates follow logistic growth law, then the goodness of fit estimations can be viewed as a quality indicator of the cancer counts reported. Of the goodness of fit (i.e., R values) of the 48 IR models listed in Table 1, only 7 of them were estimated as higher than that of the corresponding MR models (e.g., the model of IRs of lung cancer among urban males in year 2009 vs. the models of MRs of the same cancer in the same subgroup and year); poorer goodness of fit was also observed with models for rural subgroups compared with that of urban ones. These suggest that the quality of cancer counts reported by rural areas and about IRs were not as good as data from urban registry system and about MRs. Third, mathematical integration of the logistic growth equations may be used to measure overall burden of cancers. As shown in Figs. 5a-b, urban males were the hardest hit (by lung cancer) followed by followed by rural males (by stomach cancer). Fourth, the ages when the age-specific IR or MR of a cancer model reaches 5% ($A_{0.05}$), 50% ($A_{0.50}$) and 95% ($A_{0.95}$) of its highest value (P_{max}) may serve as indicator ages to inform data analysis and intervention planning. For example, $A_{0.05}$ may be used to define the starting age for some targeted interventions (e.g., screening); while the age range between $A_{0.05}$ and $A_{0.95}$of a cancer may be viewed as critical ages for stemming the epidemic.

The study suffers from several limitations. First, reported cancer incidence and mortality rates reflect not only actual prevalence of cancers but also performances of registry systems and readers are fully cautioned about potential biases

due defects with cancer registration e.g., under reporting, misclassification. Second, the time interval between the earliest (2004) cancer rates and the latest (2009) ones was only 5 years. So our findings in terms between different years may not necessarily represent long-term trends. Third, CNCRs provide similar data about 58 types of most common cancers in China. Yet our study included only four types of cancers due to space limit. Fourth, it used aggregate data extracted from published reports which did allow for more detailed analysis. For example, the study did not mention differences between sub-regions of China, e.g., differences between south and north or east and west China.

5. CONCLUSION

The study provides useful perspectives for analyzing age-specific IRs and MRs and reveals a number of interesting patterns and trends with cancer counts reported by CNCR.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDICES

Apependix A. Incidence and mortality cases by age groups, cancer types and year reporting extracted from China Cancer Registratry Annual reports

Incidence cases, mortality cases year, gender, region	Total	Age groups																	
		0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Lung cancer																				
Incidence case 2009, male, urban	22360	0	0	0	1	1	14	23	35	165	408	897	1838	2541	2579	2872	3735	3862	2305	1084
Incidence case 2006, male, urban	16433	2	2	1	1	5	5	21	43	160	356	715	1423	1602	1744	2320	3265	2781	1415	572
Mortality case 2009, male, urban	19452	0	0	0	1	0	10	10	31	96	295	661	1347	1798	1871	2358	3398	3820	2444	1312
Mortality case 2006, male, urban	14901	0	0	0	3	4	3	13	36	90	253	551	1018	1168	1362	1997	3048	3017	1637	701
Incidence case 2009, female, urban	11449	0	0	1	0	3	5	19	44	138	276	529	882	1094	1123	1284	2110	1962	1292	687
Incidence case 2006, female, urban	8166	2	5	2	1	3	5	20	43	100	248	391	619	683	726	1165	1645	1342	757	409
Mortality case 2009, female, urban	9474	0	0	0	0	3	4	8	25	81	148	309	505	639	757	957	1863	1949	1399	827
Mortality case 2006, female, urban	7115	0	0	0	1	3	6	8	21	56	154	240	407	395	529	979	1510	1437	871	498
Incidence case 2009, male, rural	8075	1	1	0	1	0	8	13	36	70	213	345	640	1025	1169	1185	1370	1183	582	233
Incidence case 2006, male, rural	3487	0	0	0	0	0	1	6	14	36	93	147	294	375	461	561	666	506	251	76
Mortality case 2009, male, rural	6921	0	0	0	1	1	4	14	27	47	163	257	486	715	917	1011	1252	1133	631	262
Mortality case 2006, male, rural	3014	0	0	1	0	0	1	5	12	34	68	95	226	301	361	460	622	484	255	89
Incidence case 2009, female, rural	3900	0	0	0	1	2	4	9	14	45	169	202	339	473	486	500	591	520	375	170
Incidence case 2006, female, rural	1518	0	0	0	0	0	2	7	10	30	65	86	143	179	163	205	229	199	127	73
Mortality case 2009, female, rural	3099	0	0	0	0	1	2	10	12	39	94	117	236	325	362	350	526	486	363	176
Mortality case 2006, female, rural	1270	1	0	0	0	0	0	3	4	21	41	64	116	143	130	161	225	188	114	59

Apependix A. Incidence and mortality cases by age groups, cancer types and year reporting extracted from China Cancer Registratry Annual Reports (continued)

Incidence cases, mortality cases year, gender, region	Total	Age groups																	
		0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Stomach cancer																				
Incidence case 2009, male, urban	11863	0	0	2	4	4	6	33	63	119	301	633	1198	1513	1445	1439	1894	1774	966	469
Incidence case 2006, male, urban	9442	3	4	0	1	2	9	19	34	115	288	546	885	989	1119	1288	1704	1430	738	268
Mortality case 2009, male, urban	8079	0	0	0	0	2	3	6	24	53	131	289	615	793	786	974	1338	1456	995	614
Mortality case 2006, male, urban	6847	0	0	0	0	2	4	7	11	52	148	286	447	548	631	855	1414	1288	780	374
Incidence case 2009, female, urban	5496	0	0	0	0	2	15	41	70	133	206	349	499	589	496	581	852	815	552	296
Incidence case 2006, female, urban	4461	2	1	0	0	3	17	38	67	109	212	299	420	416	424	505	747	663	350	188
Mortality case 2009, female, urban	4080	0	1	1	0	0	6	17	36	76	102	172	259	292	330	356	620	721	618	473
Mortality case 2006, female, urban	3315	0	0	0	0	2	7	15	44	57	91	161	233	209	213	390	563	613	436	281
Incidence case 2009, male, rural	9584	0	0	0	1	4	6	13	34	80	218	417	922	1387	1641	1513	1491	1081	572	204
Incidence case 2006, male, rural	4751	0	0	0	0	1	4	5	17	47	104	240	525	715	712	782	785	485	248	81
Mortality case 2009, male, rural	6897	0	0	0	1	3	3	11	14	41	120	220	461	787	963	1073	1220	1070	634	276
Mortality case 2006, male, rural	3603	0	0	0	1	0	0	1	9	33	77	125	322	424	509	590	674	486	253	99
Incidence case 2009, female, rural	4006	0	0	0	0	1	6	15	32	64	155	202	314	492	596	508	577	553	331	160
Incidence case 2006, female, rural	2206	0	0	0	0	0	4	6	14	50	75	94	214	254	284	344	346	282	167	72
Mortality case 2009, female, rural	3064	0	0	0	0	0	2	11	13	39	63	95	182	274	355	372	475	548	418	217
Mortality case 2006, female, rural	1770	0	0	0	0	0	5	5	7	29	41	57	141	162	207	236	323	270	186	101

Apependix A. Incidence and mortality cases by age groups, cancer types and year reporting extracted from China Cancer Registratry Annual Reports (continued)

Incidence cases, mortality cases year, gender, region	Total	Age groups																	
		0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Colorectal cancer																				
Incidence case 2009, male, urban	11407	0	0	0	0	3	18	40	80	160	322	606	1093	1307	1309	1290	1805	1788	1048	538
Incidence case 2006, male, urban	8372	0	0	1	1	6	21	32	74	138	268	468	729	799	816	1144	1605	1299	696	275
Mortality case 2009, male, urban	5490	0	0	0	0	2	6	14	34	46	94	168	366	428	493	520	902	1053	814	550
Mortality case 2006, male, urban	3787	0	0	0	0	1	4	10	14	34	80	163	198	285	273	449	755	723	524	274
Incidence case 2009, female, urban	9163	0	0	1	2	1	17	47	74	161	264	457	837	1031	964	1016	1428	1423	916	524
Incidence case 2006, female, urban	6968	0	3	1	2	7	7	26	46	152	222	421	647	673	661	945	1185	1117	561	293
Mortality case 2009, female, urban	4337	0	0	0	0	0	3	5	25	45	79	129	240	310	311	370	671	815	751	583
Mortality case 2006, female, urban	3148	0	0	0	0	1	1	8	13	37	65	133	160	237	223	364	554	606	417	329
Incidence case 2009, male, rural	2593	0	0	0	1	2	8	8	24	75	114	148	269	358	331	350	373	285	175	72
Incidence case 2006, male, rural	1084	0	0	0	0	2	1	6	14	32	52	58	113	141	124	139	177	132	63	30
Mortality case 2009, male, rural	1310	0	0	0	0	0	3	5	14	33	33	55	75	139	133	171	202	225	146	76
Mortality case 2006, male, rural	561	0	0	0	0	1	0	1	5	10	21	19	56	70	53	58	79	110	49	29
Incidence case 2009, female, rural	1996	0	0	0	0	1	10	10	14	56	83	113	192	250	259	250	273	249	161	75
Incidence case 2006, female, rural	892	0	1	0	1	1	0	7	11	34	37	46	94	99	97	115	130	113	72	34
Mortality case 2009, female, rural	1024	0	0	0	0	0	5	4	7	20	36	45	77	79	88	97	151	182	140	93
Mortality case 2006, female, rural	483	0	0	0	0	0	0	7	2	12	17	24	38	30	51	55	76	73	62	36

Apependix A. Incidence and mortality cases by age groups, cancer types and year reporting extracted from China Cancer Registratry Annual Reports (continued)

Incidence cases, mortality cases year, gender, region	Total	Age groups																	
		0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Liver cancer																				
Incidence case 2009, male, urban	11425	4	8	2	3	10	21	56	168	404	734	1203	1691	1644	1279	1052	1118	1057	652	319
Incidence case 2006, male, urban	8510	6	5	4	3	1	17	52	139	287	631	953	1183	1018	834	946	981	793	463	194
Mortality case 2009, male, urban	10268	2	6	1	1	5	18	33	98	309	554	1045	1449	1400	1092	957	1110	1105	729	354
Mortality case 2006, male, urban	8070	1	1	1	2	6	13	31	79	223	540	834	1020	891	788	874	1057	917	531	261
Incidence case 2009, female, urban	3882	1	3	1	3	0	11	11	35	61	126	202	334	404	420	423	599	585	402	261
Incidence case 2006, female, urban	2833	2	3	0	3	3	5	14	21	45	81	166	230	294	277	363	504	413	260	149
Mortality case 2009, female, urban	3617	1	2	0	0	0	8	11	17	57	97	160	275	321	353	398	585	606	424	302
Mortality case 2006, female, urban	3032	0	1	1	2	0	6	13	18	39	94	124	203	253	249	396	545	530	373	185
Incidence case 2009, male, rural	6730	1	0	1	1	6	12	42	113	327	586	684	990	975	804	696	643	480	255	114
Incidence case 2006, male, rural	3303	0	0	0	2	9	14	25	66	193	305	360	487	466	371	325	329	211	97	43
Mortality case 2009, male, rural	6141	0	0	1	0	6	10	27	85	240	508	608	841	862	774	666	605	506	266	136
Mortality case 2006, male, rural	3136	0	0	2	1	8	11	20	50	174	298	320	505	423	346	326	305	204	106	37
Incidence case 2009, female, rural	2499	1	1	1	1	1	10	2	28	52	124	177	271	304	302	315	310	294	194	111
Incidence case 2006, female, rural	1201	0	0	2	2	0	1	8	13	45	71	91	143	161	120	134	163	126	78	43
Mortality case 2009, female, rural	2229	0	2	1	1	2	6	3	17	39	92	135	222	248	267	286	307	273	198	130
Mortality case 2006, female, rural	1147	0	1	2	3	0	1	3	14	39	60	78	119	122	141	132	157	128	89	58

Apependix B. Incidence rates (IRs) and mortality rates (MRs) extracted from China Cancer Registratry Annual Reports (1/100000)

IR, MR, year, gender, region	Age groups																	
	0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Lung cancer																			
IR 2009, male, urban	0.0	0.0	0.0	0.1	0.1	0.5	0.9	1.6	6.7	16.8	34.5	76.2	132.2	194.7	300.1	424.7	569.9	639.4	565.3
IR 2006, male, urban	1.6	0.3	0.1	0.1	0.3	0.2	1.1	2.3	7.7	15.6	34.0	75.1	123.0	187.6	272.4	419.6	562.5	582.4	487.6
IR 2004, male, urban	2.8	1.9	0.1	0.2	0.2	0.8	1.2	2.9	6.6	13.5	32.9	66.1	112.9	184.4	264.4	423.1	537.4	562.2	472.6
MR 2009, male, urban	0.0	0.0	0.0	0.1	0.0	0.4	0.4	1.4	3.9	12.2	25.4	55.8	93.5	141.2	246.4	386.4	563.7	677.9	684.2
MR 2006, male, urban	0.0	0.0	0.0	0.2	0.2	0.1	0.7	1.9	4.3	11.1	26.2	53.8	89.7	146.5	234.5	391.7	610.2	673.7	597.5
MR 2004, male, urban	1.1	0.0	0.0	0.0	0.4	0.2	0.9	2.6	4.4	11.1	27.6	49.3	86.9	138.8	241.9	417.1	578.2	624.7	588.9
IR 2009, female, urban	0.0	0.0	0.1	0.0	0.2	0.2	0.8	2.1	5.7	11.6	21.2	37.5	56.3	83.1	127.4	216.7	259.7	291.4	232.5
IR 2006, female, urban	1.7	0.9	0.2	0.1	0.2	0.3	1.1	2.3	4.9	11.5	19.4	33.3	53.0	75.1	127.4	194.9	236.7	232.4	202.1
IR 2004, female, urban	0.0	2.5	0.0	0.3	0.1	0.4	0.7	2.7	4.7	9.5	16.4	33.8	51.7	81.3	130.7	191.3	232.2	239.0	193.0
MR 2009, female, urban	0.0	0.0	0.0	0.0	0.2	0.2	0.3	1.2	3.3	6.2	12.4	21.5	32.9	56.0	95.0	191.4	258.0	315.5	279.9
MR 2006, female, urban	0.0	0.0	0.0	0.1	0.2	0.3	0.5	1.1	2.7	7.1	11.9	21.9	30.7	54.7	107.0	178.9	253.4	267.4	246.1
MR 2004, female, urban	0.0	0.2	0.0	0.1	0.1	0.1	0.7	1.3	4.1	6.2	12.8	20.8	36.0	62.0	114.8	185.8	254.7	260.0	228.9
IR 2009, male, rural	0.8	0.2	0.0	0.1	0.0	0.7	1.2	3.0	5.7	17.6	30.1	66.9	123.6	183.6	236.4	363.3	461.7	428.5	335.5
IR 2006, male, rural	0.0	0.0	0.0	0.0	0.0	0.2	1.2	2.4	6.2	17.7	30.1	69.1	123.0	191.6	271.5	437.3	530.8	537.8	330.2
IR 2004, male, rural	0.0	0.0	0.0	0.0	0.0	1.0	0.7	2.8	6.7	12.4	28.4	61.9	114.8	176.3	245.1	370.1	341.6	285.8	219.6
MR 2009, male, rural	0.0	0.0	0.0	0.1	0.1	0.4	1.2	2.3	3.8	13.5	22.5	50.8	86.2	144.1	201.7	332.0	442.2	464.6	377.2
MR 2006, male, rural	0.0	0.0	0.2	0.0	0.0	0.2	1.0	2.0	5.9	12.9	19.4	53.1	98.7	150.1	222.7	408.4	507.7	546.4	386.7
MR 2004, male, rural	0.0	0.0	0.0	0.0	0.2	0.6	0.4	2.2	4.9	9.9	20.4	46.6	91.0	136.4	216.2	307.4	332.2	289.7	229.0
IR 2009, female, rural	0.0	0.0	0.0	0.1	0.2	0.4	0.8	1.2	3.7	14.3	18.1	37.0	59.9	80.6	103.1	150.2	175.9	206.1	144.9
IR 2006, female, rural	0.0	0.0	0.0	0.0	0.0	0.4	1.3	1.6	5.1	12.5	17.7	33.6	59.8	70.2	97.2	129.4	153.4	163.8	141.6
IR 2004, female, rural	0.0	0.0	0.0	0.0	0.4	0.4	0.9	1.8	5.2	7.9	17.2	28.1	47.0	56.2	83.7	122.8	124.5	116.7	80.3
MR 2009, female, rural	0.0	0.0	0.0	0.0	0.1	0.2	0.9	1.0	3.2	8.0	10.5	25.8	41.2	60.1	72.2	133.6	164.4	199.5	150.1
MR 2006, female, rural	1.8	0.0	0.0	0.0	0.0	0.0	0.6	0.7	3.6	7.9	13.2	27.3	47.8	56.0	76.3	127.1	144.9	147.0	114.5
MR 2004, female, rural	0.0	0.0	0.0	0.0	0.2	0.2	0.5	1.4	4.2	6.1	13.7	19.6	33.3	48.3	76.5	114.5	122.6	122.3	96.6

Apependix B. Incidence rates (IRs) and mortality rates (MRs) extracted from China Cancer Registratry Annual Reports (1/100000, continued)

IR, MR, year, gender, region	Age groups																	
	0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Stomach cancer																			
IR 2009, male, urban	0.0	0.0	0.2	0.3	0.2	0.2	1.3	2.9	4.9	12.4	24.4	49.6	78.7	109.1	150.4	215.4	261.8	267.9	244.6
IR 2006, male, urban	2.3	0.7	0.0	0.1	0.1	0.4	1.0	1.8	5.5	12.6	25.9	46.7	76.0	120.4	151.2	219.0	289.2	303.7	228.4
IR 2004, male, urban	0.0	1.3	0.0	0.0	0.1	0.4	1.0	3.4	6.2	11.8	26.3	50.7	72.4	105.9	134.5	197.8	250.5	280.1	205.7
MR 2009, male, urban	0.0	0.0	0.0	0.0	0.1	0.1	0.2	1.1	2.2	5.4	11.1	25.5	41.3	59.3	101.8	152.2	214.8	276.0	320.2
MR 2006, male, urban	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	2.5	6.5	13.6	23.6	42.1	67.9	100.4	181.7	260.5	321.0	318.8
MR 2004, male, urban	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.2	3.0	5.7	13.3	24.5	38.2	53.8	94.2	149.8	236.2	311.3	266.4
IR 2009, female, urban	0.0	0.0	0.0	0.0	0.1	0.6	1.7	3.3	5.5	8.7	14.0	21.2	30.3	36.7	57.6	87.5	107.9	124.5	100.2
IR 2006, female, urban	1.7	0.2	0.0	0.0	0.2	0.9	2.1	3.6	5.3	9.8	14.8	22.6	32.3	43.9	55.2	88.5	116.9	107.5	92.9
IR 2004, female, urban	0.0	1.3	0.1	0.1	0.3	0.4	1.7	4.1	5.3	9.9	15.1	22.8	32.3	37.9	52.0	77.6	97.5	111.9	73.9
MR 2009, female, urban	0.0	0.1	0.1	0.0	0.0	0.2	0.7	1.7	3.1	4.3	6.9	11.0	15.0	24.4	35.3	63.7	95.4	139.4	160.1
MR 2006, female, urban	0.0	0.0	0.0	0.0	0.1	0.4	0.8	2.4	2.8	4.2	8.0	12.5	16.2	22.0	42.6	66.7	108.1	133.9	138.9
MR 2004, female, urban	0.0	0.0	0.0	0.0	0.2	0.3	1.0	1.4	2.5	5.4	8.4	12.2	14.4	23.5	36.7	60.7	92.4	131.5	114.8
IR 2009, male, rural	0.0	0.0	0.0	0.1	0.4	0.6	1.2	2.9	6.5	18.0	36.4	96.4	167.3	257.8	301.9	395.3	421.9	421.2	293.7
IR 2006, male, rural	0.0	0.0	0.0	0.0	0.2	0.9	1.0	2.9	8.1	19.8	49.1	123.4	234.5	295.9	378.5	515.4	508.8	531.4	352.0
IR 2004, male, rural	0.0	0.0	0.0	0.0	0.0	0.4	1.2	2.8	9.8	21.9	54.6	121.7	190.4	275.6	390.1	453.3	420.5	360.5	270.5
MR 2009, male, rural	0.0	0.0	0.0	0.1	0.3	0.3	1.0	1.2	3.3	9.9	19.2	48.2	94.9	151.3	214.1	323.5	417.6	466.8	397.4
MR 2006, male, rural	0.0	0.0	0.0	0.2	0.0	0.0	0.2	1.5	5.7	14.6	25.6	75.7	139.0	211.6	285.6	442.5	509.8	542.1	430.2
MR 2004, male, rural	0.0	0.0	0.0	0.0	0.0	0.2	0.7	1.6	5.5	12.8	29.3	73.8	117.7	187.4	282.2	381.9	406.1	374.8	267.7
IR 2009, female, rural	0.0	0.0	0.0	0.0	0.1	0.6	1.4	2.7	5.3	13.1	18.1	34.3	62.4	98.9	104.8	146.6	187.1	181.9	136.7
IR 2006, female, rural	0.0	0.0	0.0	0.0	0.0	0.9	1.1	2.3	8.5	14.4	19.4	50.3	84.9	122.4	163.1	195.4	217.4	215.4	139.7
IR 2004, female, rural	1.6	0.0	0.0	0.0	0.0	0.6	2.3	3.0	6.2	11.2	20.5	36.8	73.9	104.2	145.7	174.5	212.8	176.0	117.0
MR 2009, female rural	0.0	0.0	0.0	0.0	0.0	0.2	1.0	1.1	3.2	5.3	8.5	19.9	34.7	58.9	76.7	120.7	185.4	229.7	185.0
MR 2006, female rural	0.0	0.0	0.0	0.0	0.0	1.1	1.0	1.2	4.9	7.9	11.8	33.2	54.1	89.2	111.9	182.5	208.1	240.0	195.9
MR 2004, female rural	0.0	0.0	0.0	0.0	0.0	0.2	0.9	3.3	4.7	6.5	14.8	27.2	54.0	71.9	117.8	157.3	197.7	206.2	156.4

Apependix B. Incidence rates (IRs) and mortality rates (MRs) extracted from China Cancer Registratry Annual Reports (1/100000, continued)

IR, MR, year, gender, region	Age groups																	
	0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Colorectal cancer																			
IR 2009, male, urban	0.0	0.0	0.0	0.0	0.2	0.7	1.6	3.7	6.5	13.3	23.3	45.3	68.0	98.8	134.8	205.3	263.8	290.7	280.6
IR 2006, male, urban	0.0	0.0	0.1	0.1	0.4	1.0	1.7	4.0	6.6	11.8	22.2	38.5	61.4	87.8	134.3	206.3	262.7	286.5	234.4
IR 2004, male, urban	0.0	1.5	0.0	0.0	0.2	0.6	1.3	3.6	5.6	9.5	20.1	36.1	52.9	83.3	126.2	184.0	216.1	242.6	202.7
MR 2009, male, urban	0.0	0.0	0.0	0.0	0.1	0.2	0.5	1.6	1.9	3.9	6.5	15.2	22.3	37.2	54.3	102.6	155.4	225.8	286.8
MR 2006, male, urban	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.8	1.6	3.5	7.8	10.5	21.9	29.4	52.7	97.0	146.2	215.7	233.6
MR 2004, male, urban	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.9	1.3	3.7	7.7	11.2	17.8	29.9	51.2	89.5	145.5	198.1	233.3
IR 2009, female, urban	0.0	0.0	0.1	0.2	0.1	0.7	1.9	3.5	6.6	11.1	18.3	35.6	53.0	71.3	100.8	146.7	188.4	206.6	177.4
IR 2006, female, urban	0.0	0.6	0.1	0.2	0.4	0.4	1.5	2.5	7.4	10.3	20.9	34.8	52.2	68.4	103.3	140.4	197.0	172.2	144.8
IR 2004, female, urban	0.0	1.1	0.0	0.1	0.2	0.5	1.7	3.0	4.7	10.8	17.8	32.0	47.6	69.5	93.0	141.1	166.2	168.8	124.6
MR 2009, female, urban	0.0	0.0	0.0	0.0	0.0	0.1	0.2	1.2	1.9	3.3	5.2	10.2	15.9	23.0	36.7	68.9	107.9	169.4	197.3
MR 2006, female, urban	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.7	1.8	3.0	6.6	8.6	18.4	23.1	39.8	65.6	106.9	128.0	162.6
MR 2004, female, urban	0.0	0.2	0.0	0.0	0.1	0.2	0.4	0.4	2.3	2.8	6.6	12.3	16.4	24.5	38.7	70.4	114.0	141.8	148.2
IR 2009, male, rural	0.0	0.0	0.0	0.1	0.2	0.7	0.7	2.0	6.1	9.4	12.9	28.1	43.2	52.0	69.8	98.9	111.2	128.9	103.7
IR 2006, male, rural	0.0	0.0	0.0	0.0	0.4	0.2	1.2	2.4	5.5	9.9	11.9	26.6	46.2	51.6	67.3	116.2	138.5	135.0	130.4
IR 2004, male, rural	0.0	0.0	0.2	0.0	0.3	0.0	0.7	3.4	5.5	9.5	10.6	21.0	39.9	40.2	57.5	87.0	88.1	85.0	95.5
MR 2009, male, rural	0.0	0.0	0.0	0.0	0.0	0.3	0.5	1.2	2.7	2.7	4.8	7.8	16.8	20.9	34.1	53.6	87.8	107.5	109.4
MR 2006, male, rural	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.8	1.7	4.0	3.9	13.2	23.0	22.0	28.1	51.9	115.4	105.0	126.0
MR 2004, male, rural	0.0	0.0	0.0	0.0	0.2	0.6	0.6	0.8	1.9	3.2	5.1	8.9	14.2	15.9	35.5	43.4	78.2	86.6	74.2
IR 2009, female, rural	0.0	0.0	0.0	0.0	0.1	0.9	0.9	1.2	4.6	7.0	10.2	21.0	31.7	43.0	51.6	69.4	84.2	88.5	63.9
IR 2006, female, rural	0.0	0.4	0.0	0.2	0.2	0.0	1.3	1.8	5.8	7.1	9.5	22.1	33.1	41.8	54.5	73.4	87.1	92.9	66.0
IR 2004, female, rural	0.0	0.0	0.0	0.2	0.0	0.6	2.4	3.5	5.3	4.9	9.1	15.7	28.9	36.4	44.1	61.4	56.9	64.5	54.1
MR 2009, female, rural	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.6	1.7	3.1	4.0	8.4	10.0	14.6	20.0	38.4	61.6	76.9	79.3
MR 2006, female, rural	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.3	2.0	3.3	5.0	8.9	10.0	22.0	26.1	42.9	56.3	80.0	69.8
MR 2004, female, rural	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.5	1.9	3.6	5.0	4.1	10.0	15.4	21.5	36.8	50.8	57.0	47.4

Apependix B. Incidence rates (IRs) and mortality rates (MRs) extracted from China Cancer Registratry Annual Reports (1/100000, continued)

IR, MR, year, gender, region	Age groups																	
	0	1~4	5~9	10~14	15~19	20~24	25~29	30~34	35~39	40~44	45~49	50~54	55~59	60~64	65~69	70~74	75~79	80~84	85+
Liver cancer																			
IR 2009, male, urban	2.0	0.9	0.2	0.2	0.6	0.8	2.2	7.8	16.5	30.3	46.3	70.1	85.5	96.5	109.9	127.1	156.0	180.9	166.4
IR 2006, male, urban	4.7	0.8	0.4	0.2	0.1	0.8	2.8	7.4	13.7	27.7	45.3	62.5	78.2	89.7	111.1	126.1	160.4	190.6	165.4
IR 2004, male, urban	0.0	1.5	0.1	0.2	0.5	0.7	2.7	6.5	12.5	25.5	43.0	59.3	78.0	95.1	98.4	128.5	154.7	170.4	155.5
MR 2009, male, urban	1.0	0.7	0.1	0.1	0.3	0.7	1.3	4.5	12.6	22.9	40.2	60.0	72.8	82.4	100.0	126.2	163.1	202.2	184.6
MR 2006, male, urban	0.8	0.2	0.1	0.2	0.4	0.6	1.7	4.2	10.7	23.7	39.6	53.9	68.4	84.8	102.6	135.8	185.5	218.5	222.5
MR 2004, male, urban	0.0	0.2	0.1	0.3	0.3	0.4	2.1	5.6	10.8	22.7	39.7	54.2	69.0	77.1	94.2	131.4	165.3	187.8	204.7
IR 2009, female, urban	0.6	0.4	0.1	0.2	0.0	0.4	0.5	1.7	2.5	5.3	8.1	14.2	20.8	31.1	42.0	61.5	77.5	90.7	88.3
IR 2006, female, urban	1.7	0.6	0.0	0.3	0.2	0.3	0.8	1.1	2.2	3.7	8.2	12.4	22.8	28.7	39.7	59.7	72.8	79.8	73.6
IR 2004, female, urban	1.0	0.2	0.0	0.0	0.3	0.5	0.9	1.8	3.0	4.9	7.7	12.5	23.8	28.8	36.8	57.6	70.5	81.7	67.8
MR 2009, female, urban	0.6	0.3	0.0	0.0	0.0	0.3	0.5	0.8	2.4	4.1	6.4	11.7	16.5	26.1	39.5	60.1	80.2	95.6	102.2
MR 2006, female, urban	0.0	0.2	0.1	0.2	0.0	0.3	0.7	1.0	1.9	4.3	6.1	10.9	19.6	25.8	43.3	64.6	93.5	114.5	91.4
MR 2004, female, urban	0.0	0.0	0.0	0.0	0.4	0.3	1.0	1.2	1.9	4.5	5.9	12.3	18.2	26.2	38.5	62.6	79.0	109.1	98.4
IR 2009, male, rural	0.8	0.0	0.1	0.1	0.6	1.1	3.7	9.5	26.4	48.4	59.8	103.5	117.6	126.3	138.9	170.5	187.4	187.8	164.1
IR 2006, male, rural	0.0	0.0	0.0	0.4	1.7	3.1	4.8	11.1	33.3	57.9	73.6	114.5	152.8	154.2	157.3	216.0	221.3	207.9	186.8
IR 2004, male, rural	1.4	0.0	0.0	0.3	1.2	2.5	5.5	16.7	39.0	66.6	95.8	119.4	141.5	158.1	168.8	183.7	198.6	170.0	140.0
MR 2009, male, rural	0.0	0.0	0.1	0.0	0.6	0.9	2.4	7.1	19.4	41.9	53.1	87.9	104.0	121.6	132.9	160.4	197.5	195.9	195.8
MR 2006, male, rural	0.0	0.0	0.5	0.2	1.5	2.4	3.8	8.4	30.1	56.6	65.4	118.7	138.7	143.8	157.8	200.3	214.0	227.1	160.8
MR 2004, male, rural	0.0	0.0	0.2	0.2	0.7	1.6	3.7	14.2	35.0	60.1	87.8	104.9	126.5	136.7	163.1	191.2	187.8	167.2	129.0
IR 2009, female, rural	0.9	0.2	0.1	0.1	0.1	0.9	0.2	2.4	4.3	10.5	15.9	29.6	38.5	50.1	65.0	78.8	99.5	106.6	94.6
IR 2006, female, rural	0.0	0.0	0.5	0.4	0.0	0.2	1.5	2.1	7.7	13.7	18.8	33.6	53.8	51.7	63.5	92.1	97.1	100.6	83.4
IR 2004, female, rural	0.0	0.0	0.0	0.2	0.2	0.6	0.9	3.9	7.9	14.2	21.4	29.4	43.8	44.0	65.3	82.4	97.0	84.9	83.8
MR 2009, female, rural	0.0	0.4	0.1	0.1	0.2	0.6	0.3	1.5	3.2	7.8	12.1	24.2	31.4	44.3	59.0	78.0	92.4	108.8	110.8
MR 2006, female, rural	0.0	0.4	0.5	0.6	0.0	0.2	0.6	2.3	6.6	11.5	16.1	28.0	40.8	60.8	62.6	88.7	98.7	114.8	112.5
MR 2004, female, rural	0.0	0.0	0.0	0.2	0.0	0.4	0.4	2.6	6.4	12.4	16.1	28.3	40.3	42.3	69.8	85.1	94.1	86.0	77.3

Appendix C. Integrations and indicative ages dirived from logistic growth equations

Indicators	Lung cancer				Stomach cancer				Colorectal cancer				Liver cancer			
	A0.05	A0.5	A0.95	integration	A0.05	A0.5	A0.95	integration	A0.05	A0.5	A0.95	integration	A0.05	A0.5	A0.95	integration
Incidence rate																
Urban male 2009	45.98	65.05	84.12	2941.49	41.84	62.11	82.39	1416.13	43.41	65.68	87.95	1426.41	25.57	59.33	93.10	1116.12
Urban male 2006	46.68	63.92	81.16	2723.77	43.17	61.95	80.73	1467.51	45.91	63.91	81.91	1324.19	27.75	61.36	94.97	1100.72
Urban male 2004	47.24	63.67	80.10	2637.52	41.68	62.10	82.52	1334.65	44.60	62.93	81.27	1164.04	27.68	59.07	90.46	1048.17
Urban female 2009	47.45	64.05	80.65	1308.63	42.33	64.21	86.08	583.43	42.31	63.89	85.48	1006.14	42.32	66.86	91.40	440.51
Urban female 2006	46.87	62.76	78.64	1159.12	40.40	62.05	83.70	581.72	42.30	61.23	80.15	936.05	41.82	64.06	86.30	402.17
Urban female 2004	46.47	62.30	78.13	1161.08	38.27	61.71	85.15	532.92	42.22	60.46	78.71	864.63	41.02	63.95	86.88	393.54
Rural male 2009	44.27	60.93	77.58	2230.06	41.47	56.23	71.00	2410.98	38.17	61.11	84.04	664.45	24.73	50.29	75.85	1361.26
Rural male 2006	47.00	61.33	75.67	2489.41	40.78	55.93	71.08	3018.49	41.15	63.09	85.03	732.73	25.39	48.94	72.50	1609.96
Rural male 2004	44.61	57.16	69.71	1832.62	41.44	54.10	66.77	2543.58	36.86	60.49	84.12	542.61	24.29	43.81	63.34	1515.00
Rural female 2009	40.53	61.03	81.54	990.03	40.04	58.81	77.59	986.74	37.65	58.59	79.53	474.49	34.83	60.75	86.67	598.18
Rural female 2006	38.57	60.64	82.72	887.61	41.17	56.19	71.21	1218.67	38.03	58.79	79.56	491.62	31.73	56.19	80.64	623.23
Rural female 2004	40.51	57.19	73.86	681.20	42.43	56.47	70.52	1064.54	36.71	56.61	76.50	381.84	31.41	57.24	83.07	580.58
Mortality rate																
Urban male 2009	50.53	69.40	88.28	2852.02	49.67	74.25	98.83	1215.13	55.98	79.88	103.78	905.12	31.18	67.18	103.17	1094.71
Urban male 2006	52.05	67.35	82.65	2762.06	51.38	69.69	88.00	1312.69	54.96	74.11	93.25	807.83	35.48	71.48	107.47	1166.75
Urban male 2004	51.62	66.68	81.73	2700.54	52.59	69.32	86.05	1157.82	54.93	75.29	95.65	779.78	33.35	71.49	109.63	1078.97
Urban female 2009	53.81	67.82	81.82	1232.76	53.77	76.95	100.14	549.56	56.50	77.21	97.91	629.55	46.28	69.95	93.62	443.17
Urban female 2006	52.73	66.33	79.92	1147.55	52.16	71.33	90.50	539.26	52.57	76.28	99.99	561.06	48.74	66.74	84.74	464.21
Urban female 2004	51.73	65.24	78.75	1150.15	52.05	70.62	89.18	482.11	53.27	71.40	89.53	563.03	47.07	69.28	91.48	451.73
Rural male 2009	48.20	64.26	80.31	2096.40	46.67	64.40	82.14	2130.84	51.19	71.01	90.82	439.02	25.82	56.36	86.90	1343.11
Rural male 2006	50.11	63.86	77.61	2347.26	45.01	61.64	78.28	2665.65	52.82	71.06	89.30	473.37	25.70	49.37	73.04	1542.69
Rural male 2004	46.22	59.24	72.26	1655.68	44.87	58.33	71.78	2108.88	50.17	67.51	84.86	355.08	24.10	45.31	66.52	1421.04
Rural female 2009	46.07	64.92	83.77	851.78	49.25	67.49	85.73	912.44	52.25	71.68	91.10	307.53	37.94	65.93	93.92	578.41
Rural female 2006	42.30	61.06	79.81	756.47	44.70	63.05	81.41	1129.21	47.25	69.62	91.99	322.53	34.36	62.62	90.88	648.91
Rural female 2004	44.93	60.43	75.93	641.98	44.99	61.57	78.14	1002.20	48.64	65.84	83.03	245.10	35.03	56.84	78.65	557.46

Note: Source data came from age-specific incidence rates of top ten and all cancers from China cancer registry report 2012; A0.05, A0.50 and A0.95 stands for the age when the logistic growth equation reaches 5%, 50% and 95% of its highest value respectively

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