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The Increasing Incidence of Thyroid Cancer in Sweden Revisited

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Abstract

Use of the handheld wireless phone emits radiofrequency (RF) radiation and the thyroid gland is one target organ, especially when the smartphone is used. We used the Swedish Cancer Register to study trends of thyroid cancer during 1970-2022. In women the incidence increased statistically significant during that time period with average annual percentage change (AAPC) +1.69%, 95% confidence interval (CI) +1.48, +1.95%. The increase was especially pronounced during 1999-2022 with annual percentage change (APC) +4.35%, 95% CI +3.88, +4.89%. For different age groups APC was highest in women aged 40-59 years yielding APC +5.40%, 95% CI +4.21, +6.86% for the time period 2001-2022. In men AAPC increased during 1970-2022 with +0.94%, 95% CI +0.65, +1.25%. Highest increase was found for the time period 2001-2022 with APC +3.47%, 95% CI +2.52, +4.84%. Regarding different age groups highest APC +4.42%, 95% CI +2.81, +7.34% was found in men aged 40-59 years for the time period 2002-2022. These results support a causation between radiofrequency radiation from the handheld mobile phone and thyroid cancer.

Keywords: Mobile phone, cordless phone, radiofrequency radiation, thyroid cancer, incidence

Introduction

We have previously reported on the increasing incidence of thyroid cancer in the Nordic countries with main focus on Sweden (1,2). Ionizing radiation is a known risk factor, especially for the papillary type (3). Thyroid cancer is more common in women than in men. Hormonal and reproductive factors have been proposed to explain the difference (4). In recent years use of CT and MR has also been suggested to explain the increasing incidence due to early detection (5). However, early detection would result in a later drop of the incidence curve, which has not been observed. Increased risk for thyroid cancer associated with use of mobile phones was found in a case-control study (6). In the same study interaction between genotype and environment was studied (7). It was concluded that pathways related to DNA repair were involved in he increased risk associated with mobile phone use. The relationship was observed regardless of tumour size, ≤ 10 mm *versus* > 10 mm, or latency, ≤ 13 years *versus* > 13 years. To our knowledge, this is the only study that has so far investigated the risk of thyroid cancer among mobile phone users. In the present study we updated our previous incidence data on thyroid cancer using the Swedish Cancer Register. The study was based on register data with no personal identification. Thus ethical approval was not needed.

Materials and Methods

Study design

The Swedish Cancer Register started in 1958. It is administrated by the

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National Board of Health Welfare and is updated yearly. The diagnoses are based on clinical examination including CT and MRI, surgery, autopsy, histology and/or cytology. Thyroid cancer is diagnosed with ICD-7 code 194 in the register. We studied the age adjusted incidence per 100,000 person years according to the world population for the time period 1970-2022. Thus our previous study based on 1970-2017 was now extended with five years (2).

Statistical Methods

The National Cancer Institute (NCI) Joinpoint Regression Analysis program version 5.3.0.0 (8) was used for calculations of trends in age-standardized incidence of thyroid cancer by fitting a model of 0-7 joinpoints settings in default mode. Annual Percentage Changes (APC) and 95% confidence interval (CI) were calculated for each linear segment when joinpoints were detected. Average Annual Percentage Changes (AAPC) were calculated using the average of the APCs weighted by the length of the segment. The data were log-transformed prior to the analyses of APC and AAPC. Joinpoint regression analysis was not possible to perform if there were no cases during that time period.

Results

In women the incidence increased statistically significant during 1970-2022 with AAPC +1.69%, 95% CI +1.48, +1.95% based on 15,148 cases, see Table 1 and Fig 1. Highest increase was observed in the age group 20-39 years with AAPC +2.13%, 95% CI +1.82, +2.44% for the whole time period based on 3,434 cases, see Fig 2. In general APC was highest in the most recent time period in women, Table 1. For all women APC increased during 1999-2022 with +4.35%, 95% CI +3.88, +4.89%. Similar results were obtained in the age group 20-39 years during 1998-2022, 40-59 years during 2001-2022, and 60-79 years during 2002-2022. No joinpoint was detected in the age group 0-19 years based only on 356 cases. In the age group 80+ years no statistically significant changes of APC were observed.

Also in men AAPC increased statistically significant for the whole time period 1970 to 2022 with AAPC +0.94%, 95% CI +0.65, +1.25% based on 5,865 men, see Table 2 and Fig 3. Regarding different age groups highest AAPC was found for 40-59 years old men, +1.30%, 95% CI +0.83, +1.79%. In all men highest APC was seen for the period 2001 to 2022 with

Table 1: Joinpoint regression analysis of thyroid cancer incidence in women in the Swedish Cancer Register 1970 – 2022. ICD-7 code 194. (https://sdb.socialstyrelsen.se/if_can/val.aspx). APC = Annual Percentage Change (APC 1 = time from 1970 to first joinpoint; APC 2 = time from first joinpoint to 2022 or to second joinpoint; APC 3 = time from second joinpoint to 2022); AAPC = Average Annual Percentage Change.

ICD-7	Joinpoint location	APC 1 (95% CI)	APC 2 (95% CI)	APC 3 (95% CI)	AAPC (95% CI)
194					
All women (n=15,148)	1979; 1999	2.27 (+0.50, +5.99)	-1.54 (-2.67, -0.98)	4.35 (+3.88, +4.89)	1.69 (+1.48, +1.95)
0-19 years (n=356)	No joinpoint detected	-	-	-	1.40 (+0.69, +2.14)
20-39 years (n=3,434)	1998	0.41 (-0.47, +1.03)	4.16 (+3.38, +5.29)	-	2.13 (+1.82, +2.44)
40-59 years (n=4,996)	2001	-0.94 (-1.70, -0.31)	5.40 (+4.21, +6.86)	-	1.57 (+1.22, +1.93)
60-79 years (n=4,835)	1974; 2002	9.67 (-0.23, +33.79)	-2.17 (-3.25, -1.58)	4.26 (+3.20, +5.53)	1.14 (+0.68, +1.73)
80+ years (n=1,527)	1979; 1996	2.32 (-2.69, +19.29)	-4.58 (-18.37, +1.93)	0.41 (-1.47, +2.25)	-0.92 (-1.59, -0.14)

Table 2: Joinpoint regression analysis of thyroid cancer incidence in men in the Swedish Cancer Register 1970 – 2022. ICD-7 code 194. (https://sdb.socialstyrelsen.se/if_can/val.aspx). APC = Annual Percentage Change (APC 1 = time from 1970 to first joinpoint; APC 2 = time from first joinpoint to 2022 or to second joinpoint; APC 3 = time from second joinpoint to 2022); AAPC = Average Annual Percentage Change.

ICD-7	Joinpoint location	APC 1 (95% CI)	APC 2 (95% CI)	APC 3 (95% CI)	AAPC (95% CI)
194					
All men (n=5,865)	2001	-0.74 (-1.42, -0.22)	3.47 (+2.52, +4.84)	-	0.94 (+0.65, +1.25)
0-19 years (n=103)	-	-	-	-	-
20-39 years (n=903)	1991	-1.62 (-18.53, +1.72)	3.27 (+1.09, +14.87)	-	1.27 (-0.03, +2.69)
40-59 years (n=1,801)	2002	-0.60 (-1.73, +0.17)	4.42 (+2.81, +7.34)	-	1.30 (+0.83, +1.79)
60-79 years (n=2,539)	1980; 2000	2.71 (-0.04, +10.01)	-2.55 (-6.78, -1.65)	3.32 (+2.44, +4.38)	0.91 (+0.56, +1.33)
80+ years (n=519)	No joinpoint detected	-	-	-	-1.18 (-2.33, +0.04)

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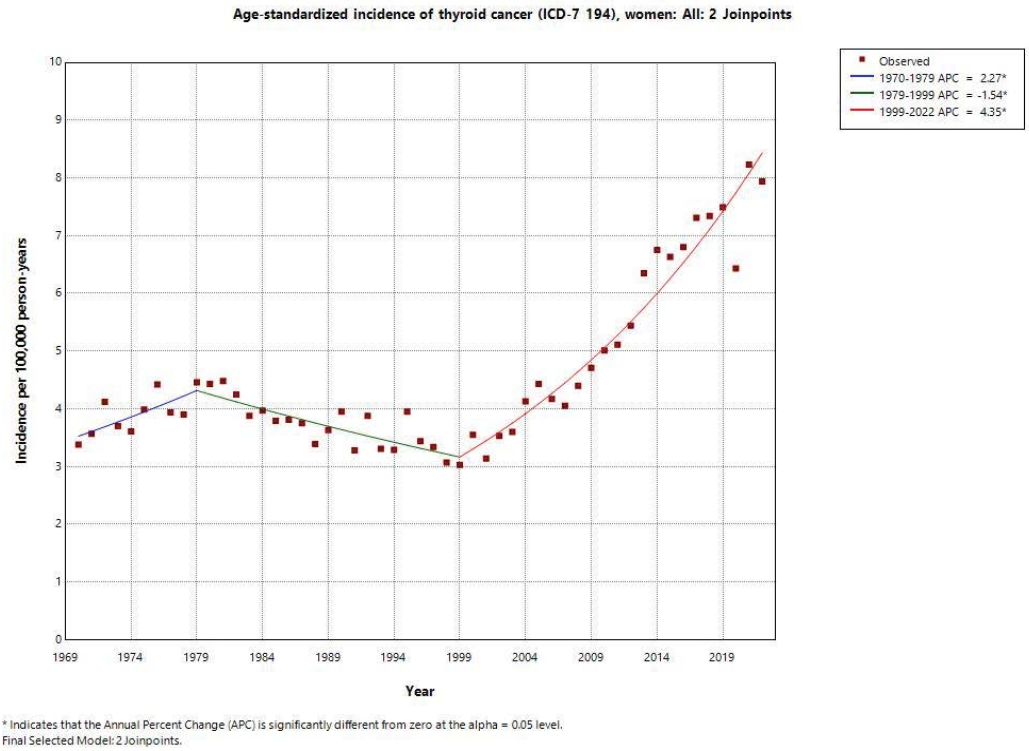

Figure 1: Joinpoint regression analysis of age-standardized incidence of thyroid cancer (ICD-7 code 194) per 100,000 inhabitants according to the Swedish Cancer Register for women, all ages during 1970-2022. (Statistikdatabaser - Cancerstatistik - Val)

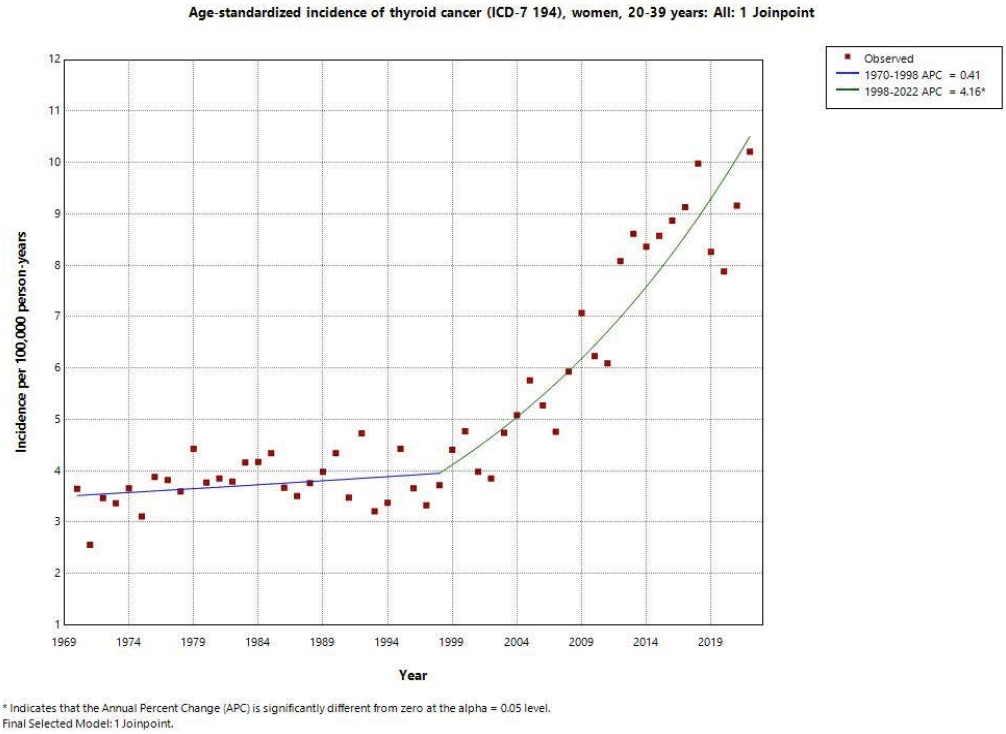

Figure 2: Joinpoint regression analysis of age-standardized incidence of thyroid cancer (ICD-7 code 194) per 100,000 inhabitants according to the Swedish Cancer Register for women aged 20 to 39 years during 1970-2022. (Statistikdatabaser - Cancerstatistik - Val)

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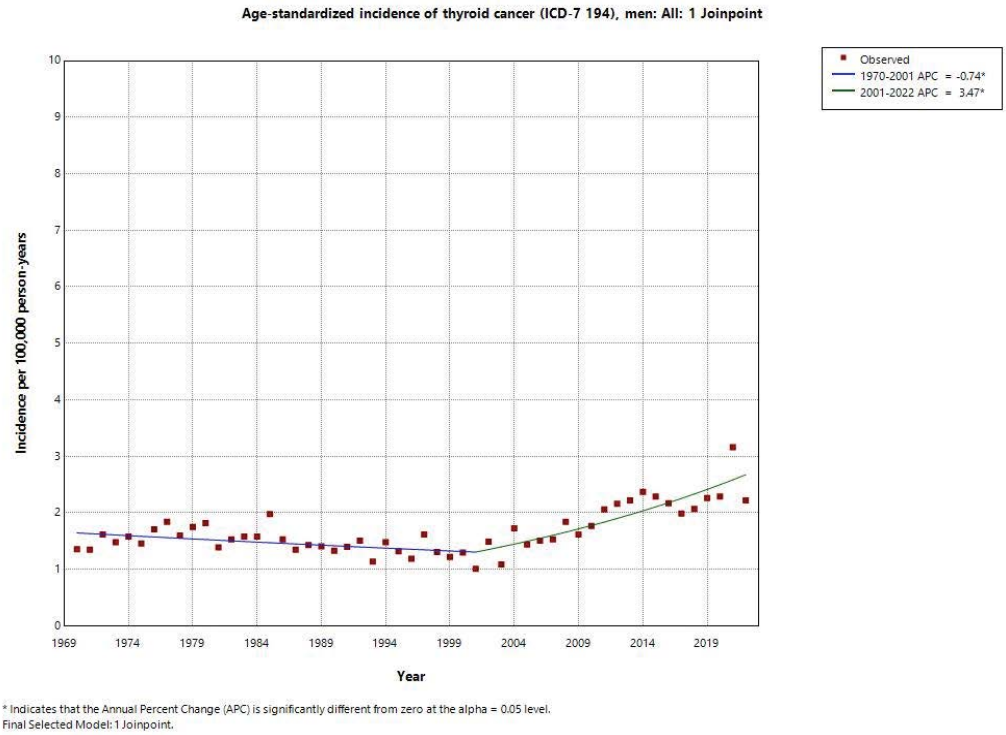

Figure 3: Joinpoint regression analysis of age-standardized incidence of thyroid cancer (ICD-7 code 194) per 100,000 inhabitants according to the Swedish Cancer Register for men, all ages during 1970-2022. (Statistikdatabaser - Cancerstatistik - Val)

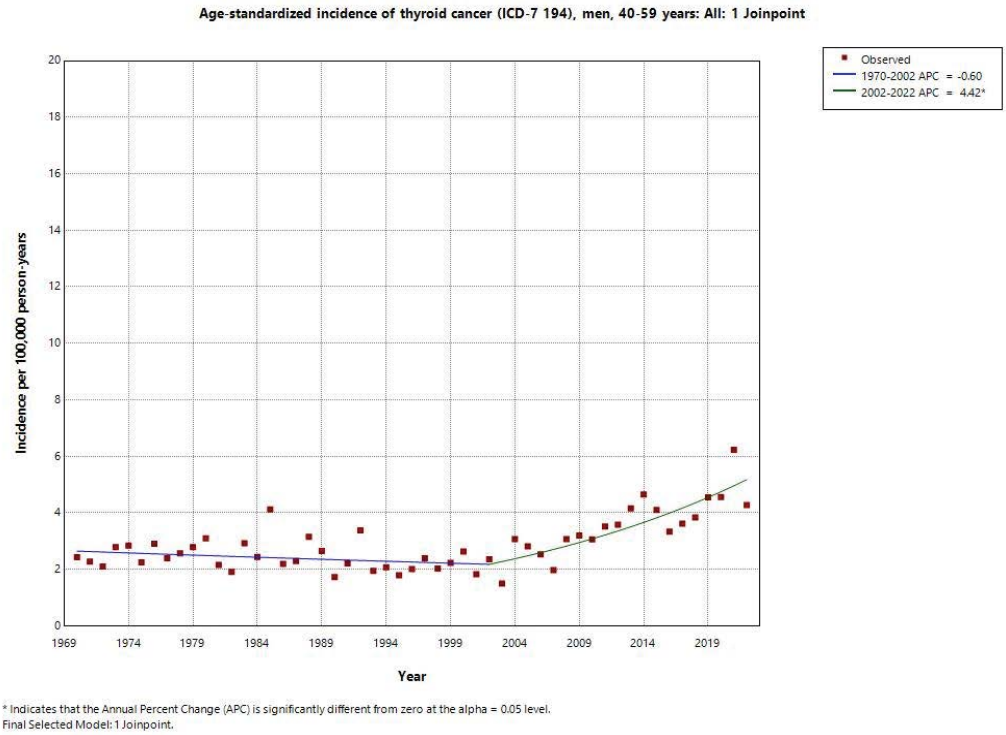

Figure 4: Joinpoint regression analysis of age-standardized incidence of thyroid cancer (ICD-7 code 194) per 100,000 inhabitants according to the Swedish Cancer Register for men aged 40 to 59 years during 1970-2022. (Statistikdatabaser - Cancerstatistik - Val)

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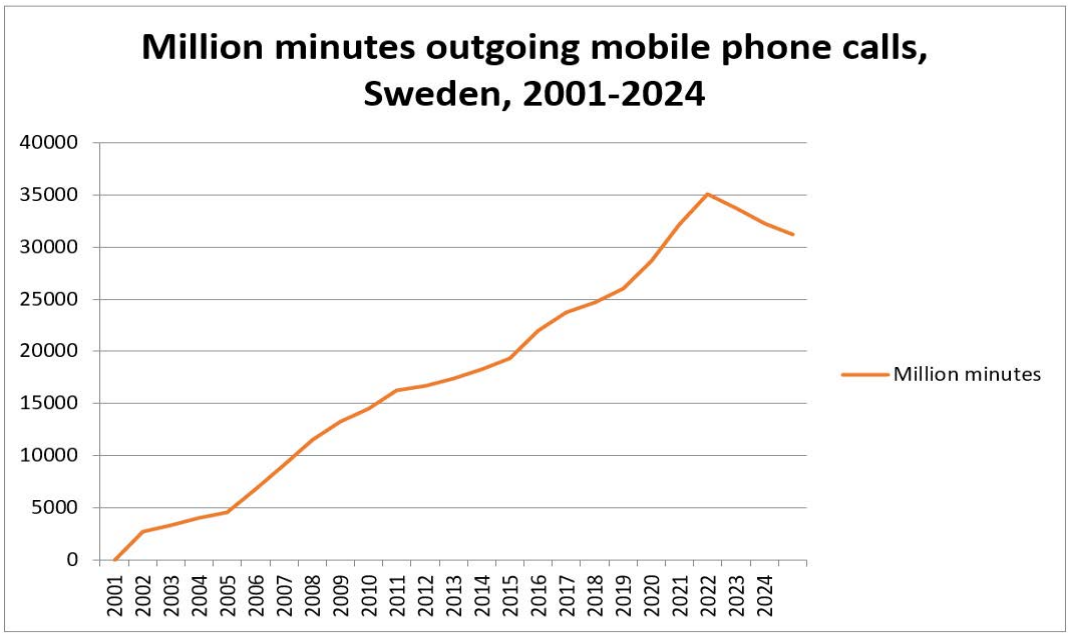

Figure 5: Outgoing mobile phone calls in million minutes in Sweden during 2001-2024. Source: Post och Telestyrelsen, The Swedish Telecommunication Market https://statistik.pts.se/en/telecom-and-broadband/the-swedish-telecommunication-market/

+3.47%, 95% CI +2.52, +4.84%. Highest APC was found in men aged 40-59 years where APC increased by +4.42%, 95% CI +2.81, +7.34% during the time period 2002-2022, Fig 4. Highest APC was found in the latest time period also for men aged 60-79 years during 2000 to 2022 yielding APC +3.32%, 95% CI +2.44, +4.38%. No joinpoint was found in the age groups 0-19 years and 80+ years, but the calculations were based on low numbers, n=103 and n=519 cases respectively.

Discussion

The main finding in this study was increasing AAPC for thyroid cancer in both women and men during the time period 1970-2022. Our latest study on this issue was based on the time period 1970-2017 (2). Extension of the time period with five years with the most recent data gave similar results. Thus the incidence continues to increase at the same rate as in previous publication. In women AAPC increased statistically significant in all age groups except for those aged 80+ years. Highest AAPC was found among women aged 20-39 years, +2.13%. Also among men AAPC increased in all age groups except in the 80+ years group. Highest AAPC was found in the age group 40-59 years with AAPC + 1.30%. AAPC could not be calculated for men aged 0-19 years due to low numbers. For 80+ years no joinpoint was detected. This is a register-based study with no individual exposure data. The results are presented for all cases but also for different age groups for both women and men. Exogenous risk factors may have caused the increasing incidence, especially for the last twenty years' time period from 1999 to 2022 in women and from 2001 to 2022 in men. Ionizing radiation is one established risk factor for thyroid cancer. The first correlation study was published already in the late 1940s. This was seen in studies on childhood x-ray treatment of scalp ringworm and the thymus, as well as among A-bomb survivors (9). A fairly short latency period of 5 to 10 years was reported with a peak about 15-25 years after irradiation, but the increased risk seems to be life-long. There are no data indicating a sharp increase of ionizing radiation exposure to the thyroid gland caused by x-rays used in medicine for diagnostic purposes. Thus our results are less likely explained by increasing exposure to medical x-rays. Of interest is that the radiation dose from x-rays has been reported to be decreased in surveys in Sweden during 2006, 2008, 2013 and 2019 (Strålsäkerhetsmyndigheten. Patientstråldoser vid röntgenundersökningar. 2020:10: Rapportnummer: 2020:10 ISSN: 2000-0456 www.ssm.se). Thus, the dose was reported to have declined with 25% to the brain and 40% to the thorax. Coronary angiography showed a reduction of the radiation dose with 80% during the same time period. In general all x-ray radiation doses had diminished during that time period. Thus, these results contradict ionizing radiation to be a major risk factor for the increasing incidence of thyroid cancer.

Another candidate for the increasing incidence of thyroid cancer is radiofrequency (RF) radiation. Smartphones have been increasingly used since the early 21st century and are now the only type on the market. According to the governmental agency Swedish Post and Telecom Authority (PTS), use of mobile phones in terms of data on outgoing million minutes

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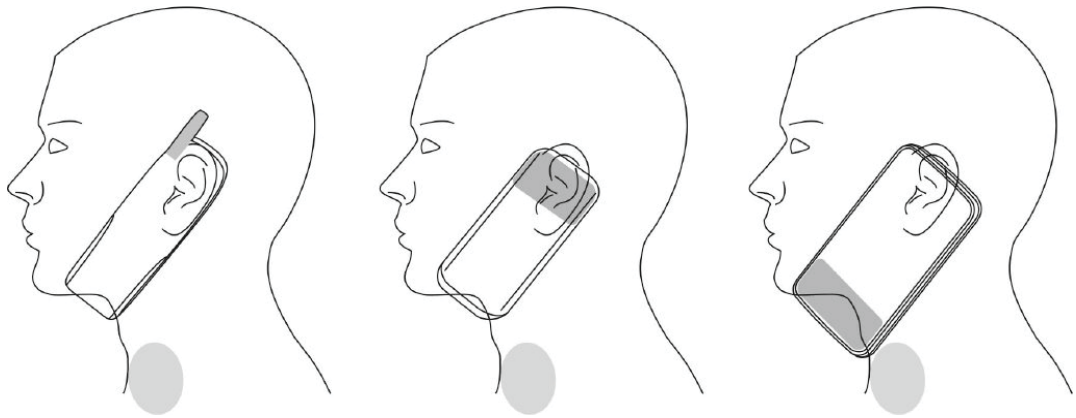

Figure 6: Mobile phone antenna placement for different generations in regard to the thyroid gland. The first model had an external antenna followed by antenna at the top of the mobile phone. The last picture shows a smartphone with antenna close to the thyroid gland.

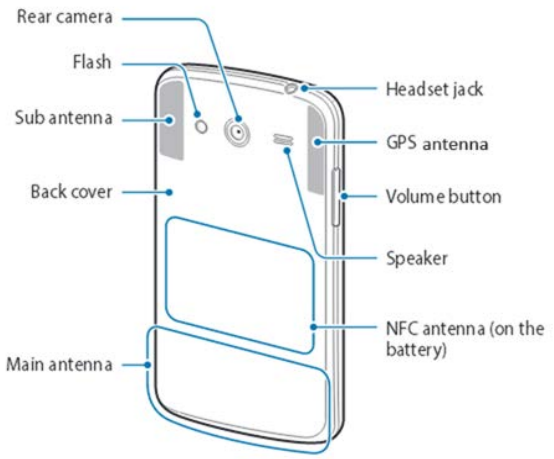

Figure7: Schematic picture of the placement of the antenna in a smartphone. The main antenna is located at the base yielding higher RF radiation exposure to the thyroid gland compared with previous models. Global Positioning System (GPS). Near-field communication (NFC).

of mobile phone calls, has increased more than ten times between 2001 and 2024. In 2001 there were 2733 million minutes outgoing calls and in 2024 31206 slightly down from a peak in 2021 with 35097 million minutes, Figure 5. The increasing trend in terms of outgoing calls matches the trend of thyroid cancers in e.g. Figure 2 during the same time period. The brain and the thyroid gland are the organs that are highest exposed to RF-radiation during the use of the handheld phone against the head (10), see also Figures 6 and 7.

As discussed above an increased risk for thyroid cancer associated with RF radiation was reported in a case-control study (6,7). These results are supported by some animal studies. Thus, these studies have indicated modified morphology of the thyroid gland associated with RF radiation with increased size of follicles (11) and with other pathological findings in the thyroid gland (12). Increased proliferation of thyrocytes was reported in one study (13). The US National Toxicology Program (NTP) on carcinogenicity of RF radiation showed a statistically significant increased incidence of C-cell hyperplasia in the thyroid gland in the two years GSM-exposed groups (14). In male animals, a statistically non-significant increased incidence of C-cell hyperplasia was observed in the 1.5 W/kg exposure group, that may be a precursor to thyroid cancer (15).

Conclusion

This study showed continuously increasing incidence of thyroid cancer in Sweden. Ionizing radiation is an established risk factor. However register data in Sweden show decreasing exposure from x-ray examinations during the last couple of decades which contradicts that x-rays would be a causative factor behind the increasing incidence. Human studies on RF-radiation from mobile phones has been reported to increase the risk of thyroid cancer and animal studies have also suggested a link. RF radiation exposure to the thyroid gland, caused by the increasing use of mobile phones, has increased substantially in parallel with the increase in thyroid cancer incidence. The smartphones cause high RF radiation exposure to the thyroid gland. Thus, RF-exposure may be a causative factor behind the increasing incidence of thyroid cancer.

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Availability of data and materials

The information generated and analyzed during the current study is available from the corresponding author on reasonable request.

Authors' contributions

All authors participated in the conception, design and writing of the manuscript, and have read and approved the final version. MC made the statistical analyses.

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Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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