



## The “pet effect” in cancer patients: Risks and benefits of human-pet interaction

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### ABSTRACT

“Can I keep my dog while receiving chemotherapy?” “Can my cat sleep on my bed while I’m on treatment?” “What precautions should I take with my pets in order to avoid infections?” “I read that my dog could give me breast cancer, is that true?” “Do you have assistance therapy dogs at your chemotherapy day unit?” These are not uncommon questions from cancer patients in oncology/haematology consultation rooms. The answers to these questions however, are widely unknown among physicians.

Pet ownership is thought to provide patients with both emotional and physical health benefits. However, owning pets may also pose health risks to immunocompromised patients through zoonotic transmission of disease. Some studies have also suggested that the ownership of domestic pets may increase the risk of developing some cancers. But what is the evidence behind these claims? This paper presents the results of a literature review of a variety of scientific literature about pet ownership as a potential risk factor for suffering cancer, zoonotic diseases and the immunocompromised, and animal-assisted-therapy in cancer patients.

### 1. Introduction/overview

Pets have become an important part of families for many reasons, including companionship, recreation, and protection. In the United States, it is estimated that approximately 79.7 million homes own a pet (65% of households) – one of the highest rates of pet ownership in the world. Similar statistics are reported in other countries (Association AVM, 2012). For instance, in Australia around 5 million homes have a pet (63% of total households) (Voice, 2019). These figures are likely to be underestimated.

Numerous studies have acknowledged the human emotional and physical health benefits from pet encounters and the improvement in quality of life. For these reasons, pets are increasingly included in the therapeutic approach to mental health problems and chronic diseases (Friedmann and Son, 2009). In patient with chronic diseases, animal assisted therapy (AAT) has been associated with a positive influence on human physiology, in particular, lowering blood pressure and heart rate. Several studies undertaken on psychiatric inpatients have also noted a reduction in anxiety levels and improved social skills (Barker and Dawson, 1998; Barker et al., 2003; Dimitrijevic, 2009; Moreira et al., 2016). Oncology patients undergo a similar path when facing the challenges of a long therapeutic journey, which greatly affect their lifestyle from both a physical and psychological perspective. AAT,

principally using formally trained dogs, has proven beneficial in cancer patients undergoing intense cancer treatment (Fleishman et al., 2015; Johnson et al., 2008; Orlandi et al., 2007).

However, earlier studies found an association between pet ownership, the risk of transmission of zoonotic diseases and acquiring cancers. Misconceptions have often resulted in families getting rid of their pets unnecessarily. Epidemiologic studies may suggest that the occurrence of pet-associated disease is low overall, but the immunocompromised population may suffer from more severe disease or complications. Surveys have revealed that most high-risk patients are not aware of the risks associated with high-risk pet practices or of recommendations about how to reduce them. This reflects a lack of communication between physicians and patients, in particular, a lack of discussion about pet contact and assessing the potential associated risks. Cancer physicians should also be proactive in enquiring about pet ownership among their immunocompromised oncology patients and offering advice as appropriate.

There are no standardized guidelines for the use of pet therapy in oncology patients receiving treatment. There has been substantial variation in practice across different healthcare settings; with some hospitals limiting visits to domestic companion animals, and others with an extensive dog therapy program (Hodgson et al., 2015). More research in this area is needed in order to better define the risks and

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benefits of allowing animals into healthcare facilities for specific purposes.

In this manuscript, we will review the available evidence regarding (i) pet ownership as a potential risk factor for acquiring cancer; (ii) the risk of having a pet at home while receiving oncology treatment as well as some general recommendations for pet owners undergoing cancer treatment and (iii) the benefits of AAT when used in chemotherapy day centers and palliative care wards and finally, (iv) we will also identify some gaps or issues to be further addressed regarding research and practice in this area.

## 2. Methods

Studies for this narrative review were included based on a literature search via Pubmed using the following key terms: *zoonotic diseases, pet-borne infections, cancer risk, pet ownership, immunocompromised patients, chemotherapy, animal-assisted activity, pet therapy*. References within each obtained article were also examined to assure that no studies were overlooked. Only published, English-language studies were included in this review.

## 3. Pets ownership and the risk of developing Cancer

Some environmental factors (ultraviolet light, radon gas, infectious agents, etc.) and occupational exposures such as asbestos, silica dust, diesel engine exhaust and wood dust are established human carcinogens. Some studies have suggested that exposure to pets could also be linked to an increased risk of suffering from cancer: birds and lung cancer, dogs and breast cancer, and cats and brain tumours or hematological malignancies.

Three European studies from the latter part of the twentieth century showed avian exposure to be an independent risk factor for lung cancer (Holst et al., 1988; Kohlmeier et al., 1992; Gardiner et al., 1992). Holst et al. (1988) was one of the first researchers to investigate whether keeping birds in the home was an independent risk factor for lung cancer. In a case-control study including 49 lung cancer patients under 65 years of age, each patient was matched for age and sex with two control subjects from the same general practice. Data were collected on social class, cigarette smoking, alcohol consumption and intake of vitamin C. It was found that smoking, birdkeeping, and a low intake of vitamin C were significantly and independently related to the incidence of lung cancer. Regarding birdkeepers, there was a 6.7-fold increased risk for developing lung cancer. Almost a decade later Kohlmeier<sup>13</sup> also concluded based on a German case-control study that pet birds were an independent risk factor for lung carcinoma. All new diagnoses of lung, trachea or bronchi cancers from West Berlin from April to October 1990 were included and interviewed in the study (239 cases and 429 controls). The interview consisted of questions on 8 main domains: healthy lifestyle, nutrition, active and passive smoking, history of keeping pet animals, occupational exposure to lung carcinogens, health status, and socio-demographic factors. With a similar research methodology to Holst, Kohlmeier found an increased relative risk of 2.14 (95% confidence interval 1.35 to 3.40) among people exposed to pet birds. Interestingly, in a more recent British study by Gardiner (Gardiner et al., 1992), only keeping pigeons at home (as opposed to keeping budgerigars or canaries) was significantly associated with an increased risk of lung cancer diagnosis (odds ratio 3.53, 95% confidence interval 1.56 to 7.98). The exact pathogenesis for the association between regular avian exposure at home and lung carcinoma is unclear but is thought to be due to the allergens and particulate matter from birds, causing hypersensitivity pneumonitis leading to pulmonary interstitial fibrosis and/or dysfunction in the lung macrophages. The latter may result in a lack of humoral and cellular immunity (Schlueter et al., 1969).

However, subsequent epidemiologic case-control studies did not support the hypothesis of an elevated lung cancer risk for keeping pet birds (Modigh et al., 1996; Morabia et al., 1998). A study by Alavanja

(Alavanja et al., 1996) for instance, reached the opposite conclusions to those in the studies previously mentioned, perhaps as a result of better research methodology. Alavanja demonstrated a significantly reduced incidence of lung cancer among those who kept birds in their bedroom. This was consistent with previous observations among farmers in the US and around the world with a lower incidence of lung cancer (Beane Freeman et al., 2012). The most recent German study by Jöckel et al. (2002) used the same questionnaire as the earlier German study by Kohlmeier et al. (1992). This allowed maximum comparability of the results. The results also indicated that pet bird keeping did not increase the risk of lung cancer. The discrepancies seen among these case-control studies are potentially due to the residual confounding risk factors, recall bias, different pet bird breeding practices, and the variation in the study design (i.e. population selection).

Similarly, several environmental risk factors from dogs have been proposed for human sporadic breast cancer. Genetic risk factors such as mutations of BRCA1, BRCA 2 genes, Li-Fraumeni syndrome associated with p53 tumour suppressor gene mutations, and the ataxia-teleangiectasia gene accounts for only 5–10% of hereditary breast cancers. Researchers have been interested in the mouse mammary tumour virus (MMTV)-like sequences that have been highly expressed in human breast cancer and have also been isolated in canine, murine, feline, and rat cells. Bartonella species was also identified as a microbial factor that promotes vascularization and prevents apoptosis of infected cells.

Based on the findings from a Norwegian study on 14,401 dogs which reported a high frequency (53.3%) of breast cancer in dogs, Laumbacher<sup>21</sup> hypothesized that there must be some transmissible factors involved in dogs which could contribute to carcinogenesis of human breast cancer. These authors compared the frequencies of pet ownership in patients with breast carcinoma with an aged matched group of female population. This study found a significantly higher frequency of dog owners among female patients with breast cancer. One theory that was proposed is the transmission from dog to human of either mouse MMTV or some type of bacteria (i.e. bartonella species) which might be promoting the development of human breast cancer. Although this study does not identify a causal link between viral or bacterial cofactors, it is plausible that they might be contributory factors and further research in this area is required.

Regarding cats, there are some studies in the 1970s expressing concerns regarding the possibility of association between domestic feline ownership and the increased risk of their human owners developing malignancies. These studies hypothesized that the cats could be hosts for feline leukaemia virus (FeLV) or feline immunodeficiency virus (FIV) and *Toxoplasma gondii*, potentially causing haematological malignancies (Bross and Gibson, 1970; Buckley et al., 1994) and brain tumours<sup>24</sup>, respectively. However, more recent studies have confirmed that there are no obvious titres of feline viruses in patients owning cats and suffering from different haematological neoplasms (Schneider, 1972, 1970; Nowotny et al., 1995; Swensen et al., 2001). *T. gondii*, a protozoan parasite, is commonly transmitted through cat contact, consumption of undercooked or cured contaminated meats, and vertical transmission. Thomas (Thomas et al., 2012) et al found a higher incidence of adult brain cancers in countries where the prevalence of *T. gondii* antibodies were high. The seroprevalence of *T. gondii* ranged from 4% to 67% among the countries included in this study and that was positively correlated with incidence of brain tumours in those countries with highest *T. gondii* prevalence. However, this research was challenged by Benson (Benson et al., 2012) who investigated the relationship between cat ownership and the incidence of brain tumours in middle-aged women. In total, 626,454 women aged 64 years on average at baseline were included in the analysis, among whom, 114,614 (18%) owned at least one cat. Their results obtained from a postal survey concluded that the incidence of brain cancer was not increased in female cat owners (RR = 0.88, 95% CI = 0.62–1.24), when compared to non-cat owners.

The first large prospective epidemiological study to date to explore

relationships between pet ownership and cancer risk was conducted by Garcia et al. (2016) in 2016. In this study, Garcia examined whether pet ownership (of dogs, cats or birds specifically) was associated with a lower risk for total cancer. A total of 123,560 participants enrolled in the Women's Health Initiative (WHI) observational study and clinical trials also took part in this study (20,981 dog owners; 19,288 cat owners; 1338 bird owners; and 81,953 non-pet owners). Results showed that there were no significant relationships between ownership of a pet and the incidence of cancer overall. It is also worth mentioning the study by Tranah et al. (2008), whose authors not only were unable to demonstrate a link between pet ownership and human cancer but actually advocated the opposite: the presence of pets and exposure to farm animals could potentially be a protective factor for the development of non-Hodgkin's lymphoma (NHL). These Stanford University and University of California scientists analyzed more than 4000 patients (almost half of whom had NHL) using in-person interviews in a population-based case-control study. Their findings showed that those who owned pets were almost 30% less likely to develop NHL.

We would like to emphasize however, that all of the studies collected in this literature review are examples of "ecological studies", considered one of the weakest designs in the hierarchy of medical research. Studies like these can suggest questions that are worth addressing in the future; at worst, they are shots in the dark that neither support nor disprove a hypothesis. Considerable caution must be exercised in interpreting these results.

#### 4. Risk of pet contact in the immunosuppressed

Pet ownership is common. As we have already mentioned in the introduction, in our setting approximately 62% of Australian households own pets. Dogs are the most common pet (around 40%), followed by cats (approximately 30%). Thirteen percent of Australian households indicate that they are planning to acquire a pet in the next 12 months (Voice, 2019). Surveys have revealed that 77% of households obtained a pet following the diagnosis of cancer (Anon., 2019).

The main concern about pet ownership in relation to cancer patients is the risk of zoonotic infections, and this may be especially true for immunocompromised patients and/or those receiving immunosuppressive treatment (immunosuppressants or chemotherapeutic agents). Humans may acquire zoonotic infections through bites, scratches, direct contact of the skin or mucous membranes with animals, contact with body fluids or secretions, contact with urine and fecal material, or inhalation of infectious droplets. There is strong evidence supporting pet sources for bacterial, fungal, parasitic, and viral pathogens. Common pathogens of concern include Bartonella species, Campylobacter, Salmonella, Giardia duodenalis, Cryptosporidium species, Pasturella, Dermatophytes, T. gondii, and Lymphocytic choriomeningitis virus (Elad, 2013a; Robinson and Pugh, 2002; Elad, 2013b).

Despite this, the occurrence of human disease attributable to pets according to patient surveys, case reports and epidemiologic studies is thought to be low overall. That said, the real numbers of immunocompromised patients affected by zoonotic infections is unknown. These cases tend to be sporadic and generally are non-reportable infections so there is little reporting and therefore little evidence. Hemsworth (Hemsworth and Pizer, 2006) concluded that immunocompromised patients are not at any additional risk from pet contact than the general population. This is consistent with the findings from a small number of studies on patients exposed to therapy dogs in hospitals (Caprilli and Messeri, 2006; Urbanski and Lazenby, 2012; Snipelisky and Burton, 2014). However, it is agreed that the disease risk is not uniform. There are other determinants of risks including the type of cancer patient, the pet species, the age of the pet, and husbandry-related and hygiene-related aspects of pet contact. The pet species that pose the greatest zoonotic risk include amphibians, reptiles, exotic animals, rodents, and young poultry, known to be carriers of

Salmonella which in patients at high risk (i.e. Gradel (Gradel et al., 2009) suggested patients with haematological malignancies) may result in severe bacteremia.

Although having pets is not a contraindication for high-risk individuals, it is essential to take additional precautions to reduce pathogen transmission. Guidelines for pet contact in high-risk individuals exist although they are minimally evidence-based and largely focus on common sense practices such as washing hands after touching animals, avoiding pet-derived secretions and avoiding contact with ill pets (Robinson and Pugh, 2002; Elad, 2013b). Recommendations are generally categorized into pet selection, contact, husbandry, and hygiene practices. In this matter, Gurry et al. (2017) conducted a 2017 study examining the rates of participation in potentially infectious activities among immunocompromised pet owners. Three different patient populations were included, one of the groups being haematological malignancies. While 80% of patients engaged in at least one potential infectious activity with their pets such as handling animal faeces or sleeping in the same bed, only 17% of patients with pets recalled receiving education regarding safe animal handling from their clinicians. This demonstrates that physicians do not regularly counsel patients about safe pet ownership and contact, and more can be done.

Veterinarians should also be involved early on in the preventative plan for reduction in zoonotic disease transmission among pet owners who are oncology/haematology patients undergoing chemotherapy. Any pet in contact with cancer patients should receive a routine annual veterinary examination, yearly stool examinations for Salmonella, Campylobacter, Giardia, and Cryptosporidium spp and vaccines as indicated by the local veterinary authority (i.e. annual booster immunizations for rabies, canine distemper and hepatitis, leptospirosis, parvovirus, adenovirus, parainfluenza and FeLV). Vets should also advise on pet desexing (spaying or neutering) at an early age to minimize roaming and interaction with other animals in the wild (Elad, 2013a; Stull et al., 2015).

Practitioners and veterinarians have an important role to play in conveying preventative health measures to oncology patients owning pets as described above. Physicians should take an active role in obtaining pet contact history during consultation and provide appropriate advice on risk reduction for zoonotic infections. In addition, public health authorities should be notified about reportable zoonotic cases, allowing specific exposures and behaviours that increase pet-associated zoonotic disease risk to be correctly identified (Stull et al., 2015).

#### 5. Animal-assisted therapy (AAT)

Pets are desirable for many reasons and the human physical and mental benefits of keeping pets have long been acknowledged. Studies have found that animal interaction exerts physiological effects on humans by reducing blood pressure and heart rate, resulting in a reduced cardiovascular disease risk (Snipelisky and Burton, 2014; Arhant-Sudhir et al., 2011). In some families, pets are important members of the household with strong bonds forged. Pets can serve as a source of support, therefore reducing stress, anxiety, and depression. This is a result of the positive neuroendocrine influence from the release of dopamine, cortisol, oxytocin, prolactin, endorphin, and phenylethylamine7 (Odendaal, 2000). The effects are similar to those of complementary and alternative medicine, where patients seek ways to regain a sense of control for their own disease, and improve their quality of life (Shneerson et al., 2013; Kamioka et al., 2014). A diagnosis of cancer is often associated with higher levels of anxiety and depression, with four-times higher depression rates reported among cancer patients compared with the general population (Blake-Mortimer et al., 1999). Similar levels of anxiety and depression have been reported among their spouses or significant halves (Glasdam et al., 1996; Kleine et al., 2019).

Therapy animals or AAT are a specific therapeutic activity which involves a highly trained animal (mainly dogs), whose target is to

improve patients' health condition through patient-animal interaction. It is a co-adjuvant therapy which can be combined with traditional medical treatments (Orlandi et al., 2007). AATs are increasingly used in hospitals with the benefits demonstrated in research studies (Kamioka et al., 2014). Most studies have been done on psychiatric and geriatric patients, although randomised-controlled trials conducted to date have been of relatively low research quality. Although therapy dog programs are common in children's hospitals throughout the United States for instance, the existing evidence concerning the effectiveness of AAT in paediatric oncology settings is very limited. In addition, there is a general lack of scientific research on how AAT may impact the therapy animals themselves. However, the few studies available on AAT specifically looking at cancer patients have suggested the potential of alleviating distress, normalizing the hospital environment, and offering helpful distraction from pain, treatment toxicities or worry (Moreira et al., 2016; Urbanski and Lazenby, 2012; Braun et al., 2009; Chubak et al., 2017).

A notable study of AAT in the paediatric oncology population is that of Moreira's study (Moreira et al., 2016). They evaluated the response of parents who accompanied children and adolescents to their appointments, as well as healthcare staff who provide direct care to the children. Responses were positive; reducing anxiety levels, providing motivation, and making adaptation to hospital environment easier. These positive effects were extended to health professionals, resulting in a better overall patient outcome.

In terminally ill patients, the pioneering works of Kubler-Ross have also suggested that the empathetic presence of animals provides emotional support and reduces fear through the phases of dying (Kubler-Ross, 1969). That was the rationale for the first pilot study conducted by Muschel in the 1980s using AAT in terminal cancer patients. There were 20 patients included in the study. The program was carried on for ten weeks, with 90-minute sessions with a trained dog each week. Only 3 patients out of 15 did not have a positive response to the animals. The reason for this was due to the fear of further bonding followed by inevitable separation, while others did not seem to bond with the dog. Pet therapy appeared to allow patients to gain a sense of well-being and feel accepted. AAT increased patients' comfort levels and adaptation to the last days of life. Engelman (2013) also studied the benefits of using AAT on palliative care patients in both in-patient and outpatient settings over the course of one year. Nineteen patients agreed to participate in the study. However, no details about the study interventions or number of sessions were provided. A clinical psychologist with more than 25 years' experience and her well-trained therapy dog took part in the study. The objective clinical observations, staff responses, and patient responses concluded that all patients reacted positively to the dog's presence. The benefits of this interaction included feeling more relaxed, less discomfort, and having a pleasant memory of home if they were an inpatient. These authors also demonstrated that patients' negative emotions were reduced and the used of pain medication decreased considerably when therapy dogs were used.

Johnson et al. (2008) investigated the potential benefits of dog visits for oncology patients receiving active treatment. This small pilot study recruited 30 inpatients (12 men, 18 women). They were assigned to receive a 15-minute session of one of three set-ups: a dog visit, a friendly human visit, or quiet reading. Outcomes were assessed through questionnaires, which found that the dog visits had more positive responses in 'making their therapy easier and feel better' than human interaction or reading time. The scores for reading sessions were lower than those for dog visits or friendly human encounters. Johnson's study outlined that these interventions were beneficial to some extent and provided a model for subsequent studies.

The first definitive study in adult cancer patients led by Fleishman et al. (2015) highlighted the merits of animal-assisted visits using the same scientific standards as rigorously designed studies. This study enrolled forty-two adult patients, of which 37 patients (25 male, 12 female) completed the six-week study, receiving daily 15 to 20-minute

animal-assisted visits accompanied by a volunteer handler. These patients had aggressive head and neck cancers, undergoing intense multimodal concomitant radiotherapy and chemotherapy. The Functional Assessment of cancer Therapy-General Scale (FACT-G) was used as a tool to compare outcomes at baseline, during therapy (at 3 weeks), and at the end of therapy (week 7). They concluded that there was an improvement in social well-being ( $p = 0.03$ ) and emotional well-being ( $p = 0.004$ ; adjusting for declines in personal well-being at each time point), despite a significant decline in both physical and functional well-being. Some patients were also able to withstand treatment for longer in the presence of a therapy dog. Analyses of qualitative responses were hugely positive, whilst others have suggested that study be extended to other individuals outside of this study. However, there was potential bias as patients enrolled had volunteered to participate and were more likely to have a higher affinity towards pets. The difficulties of implementing AATs were recognized in the study given the practicalities of scheduling AATs, without causing a delay in treatment or additional burden to AAT handlers due to time constraints caused by unforeseen circumstances.

Another study conducted by Orlandi<sup>10</sup> had a different design to Fleishman's study. Orlandi assessed the effects of pet therapy on oncological day unit patients undergoing chemotherapy. A total of 178 patients were recruited which were divided into two groups: 89 patients in the experimental group, 89 patients in the control group. Only two trained dogs were used, with their suitability to perform the scheduled activities and health condition verified before being allowed into the ward. Pet therapy sessions were carried out once weekly in a room with 8 patients, and were further divided into three 20-minute phases. Patients observed the dog doing exercise with the trainer in the first phase. In the second phase, they were allowed to play with a dog, and in the last phase, they were allowed to hold or feed a dog. A questionnaire evaluating for anxiety, depression, somatic symptoms, and aggressiveness was used. This study highlighted that the somatic symptoms did not change in the experimental group, but deteriorated in the control group. This suggests that pet therapy is effective in distracting patient's focus from the disease or related symptoms and may increase treatment compliance as demonstrated in paediatric studies. Depression rates were significantly lessened in the experimental group. Findings from this study concluded that patient anxiety, heart rate, and blood pressure was reduced in this population. These findings are consistent with results from earlier studies. Interestingly, it was noted that there was no obstruction in nursing activity or increase in waiting time or duration of chemotherapy with the use of AATs.

Some studies on AAT in cancer patients have shown more disappointing results. McCullough et al. (2018) for instance, conducted a randomized-controlled trial assessing the effects of AAT on the stress, anxiety and quality of life for paediatric oncology patients and their parents. One-hundred and six children aged 3 to 17 were recruited in the study and were randomized to receive either standard care plus regular visits from a therapy dog (intervention group), or standard care only (control group). Data were collected at set points over 4 months of the child's treatment. Measures included the State-Trait Anxiety Inventory™, Pediatric Quality of Life Inventory, Pediatric Inventory for Parents, and child blood pressure and heart rate. However, no significant differences between groups (and both parents and children) over time on any measures were observed.

The most common objections to AAT are cleanliness, animal-related allergies and the risk of zoonotic infections. The biggest concern is the potential for transmitting infectious diseases, particularly in immunocompromised patients. Over the years, a few cases of outbreaks in healthcare facilities related to zoonotic diseases have been documented. For instance, Scott et al. (1988) reported an epidemic of methicillin-resistant staphylococcus aureus (MRSA) on a rehabilitation geriatric ward where a cat roaming the facility was considered to be the possible vector for the transmission. Its paws and fur were heavily colonized by MRSA. Drusin et al. (2000) and Snider et al. (1993), respectively,

reported multiple person-to-person nosocomial outbreaks of *Microsporum canis* (ringworm) in neonatal intensive care units. The source of infection was thought to be a nurse likely infected by her pet cat. Chubak's pilot study on inpatient youths with cancer revealed that 8 of 19 patients studied developed infections within 14 days of dog visits, but none had clear associations (Chubak et al., 2017). Lefebvre et al. (2006) evaluated the prevalence of zoonotic pathogens in a group of 102 (healthy) visitation dogs from a variety of sources. They found evidence of zoonotic agents in 80% of the animals surveyed including: toxigenic *Clostridium difficile* (40.1%), *Salmonella* spp. (3%), extended spectrum beta-lactamase or cephalosporinase *E. coli* (4%), *Pasteurella* spp. (29%), *Malassezia pachydermatis* (8%), *Toxocara canis* (2%), and *Ancylostoma caninum* (2%) (Lefebvre et al., 2009).

Based on these findings, Lefebvre et al. (2008) has been heavily involved in the development of comprehensive guidelines for introducing animals into health care facilities under the auspices of infection control and risk management. Other guidelines on animals in health-care facilities are now available (Murthy et al., 2015). Amongst the guidelines that were included were recommendations for animal handlers to have proper training prior to visiting health care facilities, requirements and training courses for an animal to become an "animal-assisted therapist" and appropriate management throughout their involvement in these programs. Since these guidelines on in-hospital therapy dogs programs have been implemented, the incidence of zoonotic infections at the centres involved in the programs has been shown not to have increased (Caprilli and Messeri, 2006; Snipelisky and Burton, 2014; Yamauchi and Pipkin, 2008).

## 6. Areas for investigation

Studies from the 1980's and 1990's assessing the risk factors for cancer found a positive relationship between certain viral or bacterial zoonotic infections as a potential cause of malignancy (Holst et al., 1988; Kohlmeier et al., 1992; Gardiner et al., 1992; Laumbacher et al., 2006; Bross and Gibson, 1970). It has been argued that the methodology resulted in a degree of bias of results. These findings have been disputed with subsequent studies with better methodologies. Most of the discrepancies may have been due to residual confounding risk factors that were not identified. Many of the studies utilised questionnaires for data collection, which will be compounded by recall bias. Therefore, more rigorous study designs are required to eliminate confounding factors.

The exact pathogenesis of the environmental risk factors in cancer remains unclear. Cancers with suspected associations with zoonotic risks should be further investigated to prove or disprove the theory. Identification of the pathogenesis of the causative agent would be of added value to better understand the risk of cancer with specific environmental exposures, in particular, animal exposure (Elad, 2013a; Robinson and Pugh, 2002).

The benefits of pet therapy was first documented in a 1962 study (Levinson, 2012) and subsequent studies have consistently showed that it is a valuable treatment modality in various patient populations (Kamioka et al., 2014). Several pilot studies and few larger scale studies have demonstrated the positive impact AATs have on cancer patients who are both receiving treatment and those in the palliative phase. The exact mechanisms of how AATs exert physiological effects on human are poorly understood. It has been proposed by Stoeckel et al. (2014) that Functional Magnetic Resonance Imaging (fMRI) may allow us to examine the ways in which the brain reacts to different stimuli in both humans and animals. Other areas which may be of interest includes the examination of hormonal changes, measuring salivary cortisol and oxytocin levels. Pet interactions should reduce cortisol levels (Ruehrdanz et al., 2013; Polheber and Matchock, 2014), a stress hormone, while oxytocin levels, an indicator of love attachment, would be expected to rise during positive human-animal interactions (Beetz et al., 2012; Petersson et al., 2017).

It is acknowledged that organisations may face difficulty with practicalities of implementing a healthcare model to include therapy animals as a complementary program to support patients through their difficult journey. As such, further studies are required to examine whether AATs have a greater impact on ambulatory patients or inpatients, or whether they exert a greater benefit in certain cancer types or treatment (Lefebvre et al., 2008; Murthy et al., 2015). Similarly, interventions targeting caregivers of cancer patients should also be considered as highlighted in Kleine's systemic review (Kleine et al., 2019). Psychological well-being of patients and the burden it brings to their family members can be underestimated. Interventions as simple as social support or coping strategies to assist their caregivers have been shown to be effective. Small-scale studies have recommended a carefully tailored psychological support program aiming at partners of cancer patients as they are fundamental in providing the backbone of support. Another popular approach with increasing research interest is music therapy, which can be considered as an alternative to pet therapy. However, literature review by Gramaglia on the therapeutic effect of music therapy in cancer patients has demonstrated highly variable results (Gramaglia et al., 2019).

Although most studies have concluded that immunocompromised patients are not at additional risk from pet encounters compared with the general population, the ongoing concern for zoonotic infections in this population calls for more studies in this area to identify the risks and benefits of allowing animals in healthcare facilities. Larger-scale studies are warranted to clearly determine the proportion of human infectious diseases caused by animal contact, the identification of specific pathogens and risk factors for transmission, and the effectiveness of various practices in the prevention of disease transmission. Given the lack of recommendations for pet therapy in oncology patients and the substantial variation in practices across health organisations, this will provide us with useful information for the establishment of guidelines for safe pet handling for cancer patients. With the robust information, patients can also make informed decisions regarding the risks and benefits of pet contact.

## 7. Conclusion

The positive benefits of pet therapy on human well-being and the impact on patients with cancer have been suggested. AATs are a valuable addition to the model of care for cancer patients receiving multimodal therapy or those at the palliative phase, given their effect on emotional well-being. This supports the more widespread use of AATs in cancer treatment centres, though it is noted that this modality does not suit all patients, especially those with a fear of pets, allergies or infections. AAT is still under development and there are only a few centers worldwide which offer this service for patients undergoing treatment or facing end of life care. One of the main concerns that arises with the use of pets in the immunocompromised population is the potential threat of zoonotic infections. In this review, we also wanted to cover the subject of pet ownership as a risk factor for developing human cancers. The studies available on this matter are epidemiological and the vast majority of them dated making it difficult therefore to draw meaningful conclusions. More studies are required in these areas to further investigate and provide us with more guidance on safe pet handling for cancer patients. On balance, we conclude that pets bring more benefits to the oncology areas explored in this review than potential negative effects.

## Disclosure

Dr Tapia Rico is the owner of a French bulldog called Bruno. Dr Chan has declared no conflicts of interest.

## Declaration of Competing Interest

Both authors have declared no conflicts of interest.

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